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EAST LANSING

THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.

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THE QUARTERLY BULLETIN

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MICHIGAN STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
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TIMING IS IMPORTANT FOR SUCCESSFUL APPLE SCAB SPRAYS[1]

By DONALD CATION

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

IN COMBATING fruit diseases, the timing of sprays in accordance with the properties of the fungicide used determines the degree of control obtained. A few well timed sprays may give as good or better control than more sprays improperly timed. Poor control is frequently the result of tardy application.

The purpose of this article is to show a comparison of spray materials used in one orchard and, also, to present the spray program followed in another orchard where spray applications were timed according to the infection periods.

SPRAY MATERIALS COMPARED

The grower today has a wide choice of spray materials for controlling apple scab. Different materials may be used with comparable effectiveness according to the stage of growth, the possibility of injury, the degree of protection required, the presence of additional diseases requiring control, and the compatibility with the insecticides used. Some fungicides must be applied before an infection period occurs, in order to provide a protective coating which will prevent scab spores from germinating and becoming established. Some fungicides have an eradicative action and may be applied several days after infection occurs. Other fungicides have both a protective and an eradicative action. Eradicants and protectants are sometimes combined in the spray tank to achieve a dual-purpose effect.

The performance expected of the several types of fungicides for scab control is illustrated, for all practical purposes, in Fig. 1. In this diagram the organic mercuries, such as Tag, Coromerc and Puratized Apple Spray, are shown as eradicating infections that were established

[1]Contribution 54-4, Department of Botany and Plant Pathology, Michigan State College.

ARTICLE 36-44

during the three previous days or approximately 72 hours before the time of application. These organic mercuries are not, however, considered as being reliable for further continued protection. Lime-sulfur has an eradicative action equivalent to that of the mercuries, but the eradicative action of Phygon is considered to be somewhat less—or for about 48 hours. In addition, lime-sulfur and Phygon leave protective fungicidal deposits. The fungicides such as the wettable sulfurs, Ferbam, Glyodin and Captan are considered to be protective only, having rather limited or no eradicative properties. The effective period of protection for the different fungicides is variable, depending on the amount of the chemical washed off by rains and the rate of new growth unprotected by the fungicides.

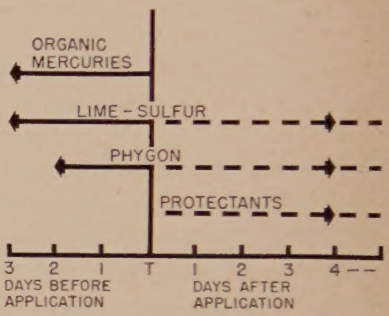

Fig. 1. Approximate periods of control of apple scab by different kinds of fungicides. (T = time of application.) The time to the left of the vertical line indicates the approximate period of eradicative action; that to the right indicates the approximate period of protective action.

COMPARISON OF SOME FUNGICIDES IN 1953

In 1953 all degrees of success or failure of spray programs could be observed in Michigan orchards. Many growers considered it a difficult year for achieving scab control. Several fungicides were compared on McIntosh, Delicious and Jonathan trees in 1953 in the Morrison orchards, near Paw Paw, Michigan. The applications were made according to the known fungicidal capacity of the materials in relation to the periods of infection. Infection was assumed to occur when the number of hours during which the foliage was wet and the approximate prevailing temperature coincided with the data given in Table 1.[2] The eradicative fungicides were applied a few days, or 48 to 72 hours, after infection was assumed to have been established. The protective fungicides were applied as often as necessary, as determined by the amount of unprotected new growth exposed or when the fungicide deposit was considered to be insufficient because of heavy or frequent rains.

[2]This table is also Table 1 of Mitchell, A. E., Franklin Sherman III, and Donald Cation (1953). 1953 Spraying Calendar. 10th rev. Mich. Coop. Ext. Serv. Bul. 154. 66 pp., p. 24.

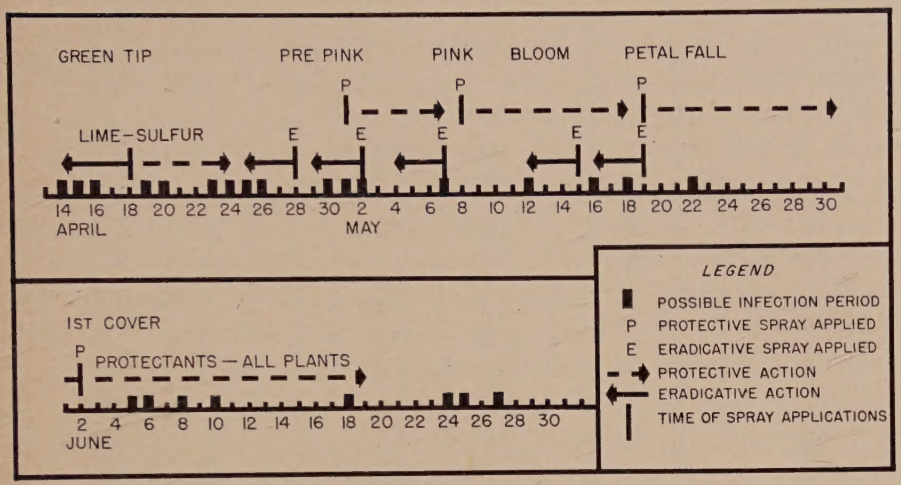

Fig. 2. Application of apple sprays in relation to rainfall and possible periods of infection by the apple scab fungus. Successive stages of tree growth are indicated. Experimental plots of McIntosh and Delicious trees near Paw Paw, Michigan, 1953.

Figure 2 shows the timing given for the several kinds of spray materials in relation to the estimated infection periods as determined by rainfall.

Inasmuch as all of the materials to be compared were not available at the beginning of the season, all trees received the same spray treatment for the first two sprays. Lime-sulfur was used for the first spray, and one of the organic mercuries for the second. The comparative eradicative and protective treatments were started at the prepink stage.

TABLE 1—The approximate number of hours of continued wet foliage required for primary apple scab infection at different air temperature ranges

Air temperature range during wet period	Number of hours of continued wet period required for primary apple scab infection
32°—40° F.	48 hours
40°—42° F.	30 hours
42°—45° F.	20 hours
45°—50° F.	14 hours
50°—53° F.	12 hours
53°—58° F.	10 hours
58°—76° F.	9 hours
76°—	11 hours

TABLE 2—Comparison of spray materials, Paw Paw, Michigan, 1953

Materials	Leaf scab on McIntosh		Fruit scab on		Dates of rains and spray applications
	Primary infection	Secondary infection	McIntosh	Delicious	
	percent	*percent*	*percent*	*percent*	Rains: April 14, 15 and 16
1. Creme Sulfur, 5 lb.	7.0	12.0	4.0	1.7	April 18: Silver tip—Lime-sulfur, 2½ gal., on all trees
2. Creme Sulfur, 7½ lb.	10.0	13.0	4.1	1.3	Rains: April 19, 20, 23, 24, 25, 26
3. Creme Sulfur, 10 lb.	7.0	12.0	3.6	6.0	April 28: Delayed dormant—Coromerc, ½ lb., on all trees
4. Mag. 70, 4 lb.	2.0	6.8	3.1	4.9	Rain: April 30
5. Mag. 70, 7 lb.	2.0	3.2	3.6	1.9	May 1: Prepink—Protectants on Plots 1 to 8
6. Mag. 70, 4 lb. + Captan, ½ lb.	2.1	0.8	3.7	2.4	May 2: Prepink—Eradicants on Plots 7 to 15
7. Spike Sulfur, 7 lb.	2.1	2.6	3.3	2.7	Rains: May 1, 2, 3, 7, and 8
8. Crag, 1½ qt.	0.9	3.0	1.4	*	May 7: Pink—Eradicants on Plots 14 and 15 only
9. Crag, ¾ qt. + Coromerc, ¼ lb.	0.5	1.1	2.6	0.0	May 8: Pink—Protectants on remaining plots
10. Captan, ¾ lb. + Coromerc, ¼ lb.	0.5	1.1	2.6	0.0	Rain: May 12
11. Phygon, ½ lb.	0.5	0.9	3.2	0.4	May 15: Mid-bloom—Mercurics on Plots 14 and 15 only
12. Phygon, ¼ lb. + Mag. 70, 4 lb.	1.2	1.2	2.6	0.5	Rains: May 16 and 18
13. Phygon, ¼ lb. + Ferbam, ¾ lb.	1.1	2.5	1.3	0.5	May 19: Petal fall—Sprayed all plots
14. Coromerc, ½ lb.	0.3	1.7	1.4	0.0	Rain: May 22
15. Tag, ½ pint	0.7	0.7	3.3	0.0	June 2: First cover—Protectants on all plots. Crag on Plots 8 and 9; Ferbam on 13; Captan on 10, 11, 12, 14 and 15
16. Check†	26.0	96.8	25.8	*	

*Tree removed from experiment.
†Received first two sprays only.

The materials and dosages are given in Table 2. The eradicants were discontinued after the petal fall stage, and protectants were substituted for them in the first cover spray. This change was made because the organic mercuries, owing to their poisonous properties, are not approved for use on formed fruit and, also, the possibility of warm weather after petal fall makes the application of organic mercuries or Phygon somewhat hazardous in respect to injury.

It is believed that the two early sprays had much influence on final control because conditions were favorable for infection during those periods. Lime-sulfur was applied on April 18 to kill the possible infections initiated during the prolonged cold rains of April 14, 15 and 16. At this time, only small green tips of leaves and sepals were exposed in the buds. The lime-sulfur also gave protection for the period of the rains of April 19, 20, 23 and 24. By April 25 it was assumed that this protection was exhausted since considerable new growth had developed. Therefore, an application of a mercury compound (Coromerc) was given on April 28 to eradicate the infections resulting during the wet weather of April 25 and 26.

The trees were then divided into randomized plots, and comparative treatments were started on May 1. The wettable sulfurs and Glyodin were applied on the morning of May 1 and were presumed to have stopped the infection occurring during the previous night. Because the length of their eradicative period is considered to be 36 hours, the combination fungicides containing half-strength eradicants were applied later in the day than were the protectants. There was ample time for the full-strength eradicants to be effective when they were applied on May 2.

During blossoming there were three periods of possible infection. The first one was conditioned by the rain of May 12; for this the protective fungicides, including Phygon, applied 4 days earlier, were considered to be functioning. However, the status of the mercury-treated plots was in doubt and, consequently, they were given an additional application on May 15 to permit the 72-hour eradicative action of the organic mercuries to counteract the May 12 infection. Light rains occurred on May 16 and 18 with possible infections. This infection period was 11 days after the protective applications of May 8. If the protection was weak after 11 days, the discharge of primary scab spores (ascospores) was also dwindling at that time. A very light infection could be expected only if the previous scab infections

had been well controlled and secondary spores were virtually absent. All plots were sprayed on May 19, and the eradicative sprays were considered well timed for the rains of May 16 and 18.

Only one rain fell during the 14-day period between petal fall and the first cover spray. Several rains occurred after the first cover spray, a period when primary spore discharge was believed negligible. No further applications were made, but at least one more would have been desirable during the rainy and cloudy week of July 29-August 5, because several weeks later considerable secondary scab infection appeared on the leaves of terminal shoots. The extent of this infection, shown in Table 2, indicates that early control is reflected in less secondary infection. Good early control means few secondary spores will likely be present at later dates. The mid-summer infection period was not sufficient to induce late scab on the fruits, frequently referred to as pin-point infection.

The materials[3] compared and the results obtained are presented in Table 2. This table shows the dosages of the materials and the resulting scab on fruit and foliage. Most of the materials gave excellent control. The data indicate that Creme Sulfur as formulated was not adequate for best results. The degree of control would be considered good for all the other materials, and the differences are small. The results indicate that the timing of the sprays was about right in respect to the estimated properties of the different fungicides.

SUCCESSFUL SCAB CONTROL IN AN OCEANA COUNTY ORCHARD

At Shelby, Michigan, where the seasonal advancement is 7 to 10 days later than that at Paw Paw, many orchards showed unsatisfactory scab control. The spray program for one McIntosh orchard is of interest. The grower has but 30 trees which had not been sprayed the year before, and as these constituted only a minor portion of his orchard he was gambling on the effectiveness of a few sprays and really expecting mediocre control. However, control was excellent in spite of a heavy carry-over of inoculum as indicated by the 100-percent

[3]Creme Sulfur is a colloidal sulfur paste containing 50 percent sulfur and is similar to a form of colloidal sulfur currently produced in New Zealand. Coromerc is a powdered mercury compound. Spike sulfur is a wettable sulfur containing Coromerc. These three materials were furnished by the Pittsburgh Plate Glass Co., Corona Chemical Division. Magnetic 70 Sulfur paste was supplied by Stauffer Sulfur Co. Captan is a wettable powder fungicide distributed by California Spray Chemical Co. and Stauffer Sulfur Co. Glyodin (Crag 341) is a product of Carbide and Carbon Co. Phygon is a product of the U. S. Rubber Co. Tag is a liquid mercury compound, a product of the California Spray Chemical Co.

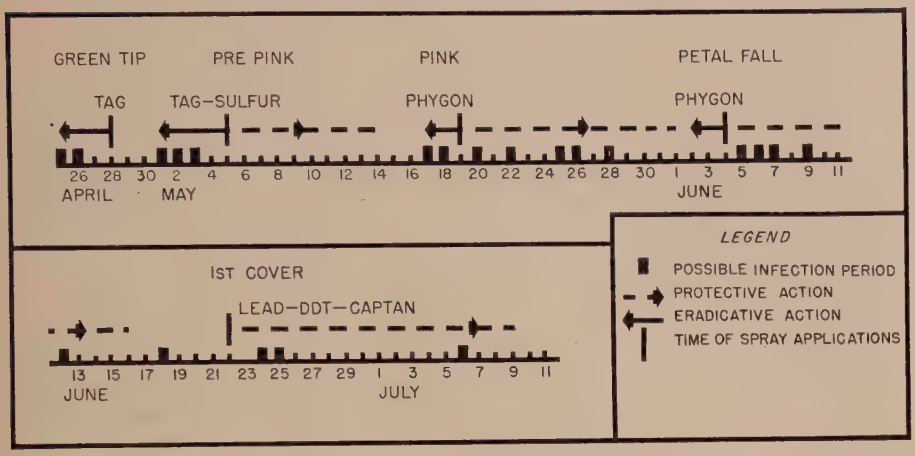

Fig. 3. Application of apple sprays in relation to rainfall and possible periods of infection by the apple scab fungus. Successive stages of tree growth are indicated. Commercial planting of McIntosh trees near Shelby, Michigan, 1953.

infection on fruit and leaves of unsprayed trees. The spray program is diagrammed in Fig. 3.

In this vicinity the first infection period occurred with the rains of April 25 and 26 when the buds were exposing green tips. An organic mercury spray (Tag, ½ pint in 100 gallons) was applied on April 28, or within 72 hours after infection was established. Another mercury spray of the same strength plus 3 pounds of wettable sulfur was applied on May 5 to counteract the presumably heavy infection occurring on May 2 and 3. The following two weeks were fair, with but little rain. On May 19 Phygon (½ pound in 100 gallons) was applied during the pink bud stage, to provide eradicative action for the probable infections resulting during the rains of May 17 and 18. This spray also gave protection for the ensuing rainy periods when the trees were in the early bloom stage. Another Phygon and lead arsenate spray at the petal fall stage provided protection for the several rainy periods following, but primary ascospore discharge was about finished at that time. This petal fall spray apparently completed the scab control job, for there was almost no scab present 19 days later when a spray (lead arsenate and DDT plus Captan) was applied primarily for insect control. The Captan was added for scab and may or may not have been necessary. Incidentally, the insect control, particularly that of curculio, was inadequate. Lead arsenate was applied in mid-summer for apple maggots. Scab control was still complete at harvest time.

SUMMARY AND DISCUSSION

Satisfactory scab control was obtained in the two Michigan orchards with any one of several materials, combinations of materials in the same spray, or different materials used in separate applications. However, the timing of the sprays was in accord with the fungicidal capacity of the materials used. The use of lime-sulfur in the delayed dormant spray at Paw Paw provided economical eradicative and protective action at a time usually critical for control and when it could be expected to give little injury. The proper use of eradicants gave satisfactory results. With good timing of applications, the organic protective fungicides can be expected to control scab. They are suggested especially for the later applications when there is danger of scald and burning from wettable sulfurs. Good control during early stages of foliage development is usually the key to a successful scab program.

FROST PROTECTION BY SPRINKLER IRRIGATION: A FIELD SURVEY

By WALTER BILANSKI, JOHN R. DAVIS and E. H. KIDDER[1]

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THIS article presents the findings of a field survey, made in lower Michigan in August 1953, concerning frost protection by sprinkler irrigation. The purpose was: 1) To obtain additional information to verify present conclusions; 2) to study farmer experiences under actual field conditions, and 3) to determine the influence of such irrigation on crop production.

The senior author conducted personal interviews with 34 farmers, who were considered to be representative of persons in Michigan using irrigation for frost control. Sixteen of them operate farms in the northwestern part of the Lower Peninsula, and the other 18 have farms in the southwestern part of the state. The crops reported in this survey are representative of those which have been protected by irrigation in western Michigan.

Twenty-eight of the growers irrigated strawberries, and seven of that number used the system to protect also cucumbers, tomatoes, garden crops, and gladiolus. The 28 growers irrigated an average of 8 acres for frost control. Those who irrigated plantings of celery, gladiolus, chrysanthemums and hydrangeas covered from ¼ to 2 acres for frost control. The range in acreage irrigated for frost protection varied from ¼ acre of hydrangeas to 60 acres of strawberries.

A few of the crops listed above were damaged because of extreme ice load or unfavorable crop and weather conditions. Of the 34 farmers, only 6 reported crop damage in the irrigated area. Exposed gladiolus petals and chrysanthemums suffered extensive damage. The two celery growers discontinued irrigating after the first night's run because of the heavy ice load which bent the outer stems. Several farmers reported crop damage only where a plant had been stepped on when

[1]Graduate assistant, instructor, and associate professor, respectively, in the Department of Agricultural Engineering, Michigan State College. The authors express appreciation to Dr. Karl A. Vary, of the Department of Agricultural Economics, for assistance in planning the survey and for reviewing the manuscript.

ARTICLE 36-45

it was covered with ice. Damage due to operational technique was reported in only two instances.

APPROXIMATE DATE OF USE

The observed dates of killing frost varied considerably from year to year and from one location to another. Strawberry growers reported using irrigation for frost control as early as May 5 and as late as June 22. The majority of the berry growers, however, used their irrigation system for frost control in late May and early June. The extreme dates reported were April 15 by a tomato grower and October 15 by a celery grower.

TEMPERATURES PROTECTED AGAINST

All growers measured the air temperatures to determine when to start irrigating for frost protection.[2] Twenty-seven reported measuring the temperature in the field at about plant level. Minimum temperatures reported during the time when the frost control practice was being carried out varied from 15° to 30° F. The majority of the growers operated at or above 20° F.; the median minimum operating temperature was about 24° F.

Gladiolus and chrysanthemum growers reported damage when the temperature at plant level reached a minimum of 25° F. At this temperature the large accumulation of ice on the plants caused considerable damage. Two celery growers reported minimum temperatures of 15° F. They reported that a heavy ice load formed and bent over the outer stalks. Other growers reported that hydrangeas were completely protected down to 20° F., strawberries to 18° F., and tomatoes to 20° F. Some of the damage that was reported on crops other than flowers when the temperature was above 20° F. was apparently due to improper design of irrigation equipment.

CROP DAMAGE OUTSIDE THE IRRIGATED AREA

Comparison of damage that occurred before the irrigation system was purchased or which happened in neighbors' fields was reflected by growers' opinions expressed in the survey. About 20 out of 25 farmers were of the opinion that the unprotected areas suffered about 100 percent loss, while others estimated a loss of 40 to 80 percent in unprotected areas.

[2]The accuracy or validity of the temperature measurements was not determined in this survey.

IRRIGATORS' OPINIONS AS TO THE TIME REQUIRED FOR THE IRRIGATION SYSTEM TO PAY FOR ITSELF IN FROST PROTECTION

Sixteen growers estimated that the irrigation system was paid for in one year; two growers estimated two years. Seven growers qualified their estimate by reporting the time to be dependent on the weather. Five growers stated that irrigation for frost control would never compensate for the cost of the irrigation system. Three of these five were gladiolus growers, who reported irrigation for frost control as having been satisfactory for only light frosts. The other two had experienced failure because of improper operating techniques.

All of those reporting in this survey believed an irrigation system to be a worth-while investment. However, only 18 out of 30 believed that an investment in an irrigation system for frost protection alone would be economically sound. This opinion was definitely divided geographically; 80 percent of those in the more northerly counties thought it would be a sound investment, while only 43 percent of those in the southern counties concurred because of less frequent and less severe frosts and earlier dates of the last killing frost in the spring.

ADJUSTING THE GROWING SEASON

One of the advantages of irrigation for frost protection reported by farmers was that one could plant earlier or harvest later to take advantage of a more favorable market. One grower planted tomatoes 1 week earlier than usual, another grower 2 weeks earlier, and another 3 weeks earlier. A fourth grower stated that harvest was prolonged 2 weeks by the protection irrigation offered against an early fall frost.

FREQUENCY OF USE OF IRRIGATION FOR FROST CONTROL

The number of years during which the system was used for frost protection and the number of years since the system was purchased may be expressed as a ratio. This ratio varied from 1 year out of 7, to 12 years out of 12. The average for all replies is about 3 years out of 4. There seemed to be some relationship between use and geographical location; but from the replies, elevation seemed to be the more deciding factor. Many of those interviewed stated they were in "frost pockets," or in areas into which cold air would drain, thus increasing the frost hazard considerably.

During each year that frost control was necessary, the irrigation system was operated one to eight times. However, the majority of growers stated that frost protection was necessary only once. Most of them commented that this factor should not be considered in designing or planning the irrigation because frosts are too unpredictable for one to plan to use the equipment for only one night every year.

OPERATING TIME AND LABOR REQUIREMENTS

Farmers reported that the length of time the irrigation system is operated for frost protection is of prime importance in planning labor requirements and in planning measures to counteract the effects of water accumulation. The operating time, they asserted, depended on the severity of the temperature drop, cloud cover, wind and other weather conditions, and on operation techniques. The operating time varied from only 3 hours to 24 hours; the majority of growers operated the irrigation system less than 10 hours each time.

The average operating time for all conditions was about 7.6 hours. However, most irrigators did not plan for the average time but irrigated according to air temperature conditions. Regardless of the operating time, the number of persons required to operate the system remained the same. Thirty growers stated that only one man was required to operate the system, which does not include the labor required to set up the system. Five men were required to operate the system on the 60-acre field of strawberries, previously mentioned.

EFFECTS OF WATER ACCUMULATION

Application of excess water or water accumulation was reported by 27 growers. Seven of them stated that they had observed the following harmful effects:

1. Bacterial action in the soil was delayed, as well as was the maturity of strawberries.
2. The soil was caked; tomatoes became soft and spoiled before they could be harvested.
3. Celery and spinach turned yellow, thus showing the need for supplemental nitrogen.
4. The field became very muddy after 3 successive nights of irrigation.
5. The soil became excessively wet when a large sized sprinkler was used.

6. Leaf spot appeared on strawberries after 5 successive nights of operation.

7. Nitrogen was leached from the soil after 4 successive nights of operation.

The determination of excess water application was based on comments regarding sprinkler size and waterlogging of the soil. Specific information on the rate of water application was generally not available; hence, it is difficult to analyze the effects of water application rate on crop or soil damage. The majority of those reporting conditions of waterlogged soil indicated that the effect was due to water applications on successive nights, rather than to high application rates.

ACCUMULATED ICE THICKNESS

Parts of tall-growing plants, such as flowers, celery, corn and pole beans were often bent down, broken or torn off from the rest of the plant. The reported ice thickness on plants varied from ⅛ to 1 inch. Nineteen growers reported ice loads as thick as ¼ inch: four growers reported a thickness of ½ inch.

No correlation was evident between the ice thickness and the observed minimum temperatures. A combination of excess water application rate, length of operating time, and low temperatures seemed to exert a considerable influence on ice formation.

OPERATIONAL TECHNIQUES

A. TIME REQUIRED FOR SETTING UP EQUIPMENT IN THE FIELD

The farmers considered that preparedness is decidedly essential. Usually the irrigation equipment had been idle for some time; so it was necessary to set up the entire system and put it into operation before it was actually needed for frost protection. This was done in order to be sure that the engine would start and all parts of the system function properly. Frosts often come without much warning. Many farmers commented that if the irrigation system is not ready for immediate operation, time may be too short to get the equipment in readiness for an unexpected frost. Through experience, they have realized that the equipment should be set up in the field well in advance. Most of them reported having set up their equipment as early as possible—that is, before blossom or bud formation; immediately after mulching, before a frost hazard, or just after setting plants out in

the case of celery and tomatoes. Three growers waited until the frost was predicted. Most growers felt, however, that following this practice may be gambling on the accuracy of weather forecasts and also on their ability to get the equipment operating without difficulty on short notice. Several growers stated that when they first used an irrigation system, they were lax in getting it set up in advance and depended too much on forecasts. In many cases, extensive frost damage occurred, and as a result, those growers are now very much aware of the need for adequate preparation.

B. STARTING THE IRRIGATION SYSTEM

The proper time to start irrigating was reported as being a very important part of the operational technique. Starting time, based on air temperatures at plant level varied from 28° to 36° F. Twenty-six growers started the irrigation system at or above 32° F., with the median starting temperature being between 32° and 33° F. Seven growers who started the irrigation system below 32° F. reported no crop damage. However, other growers reported that their previous experiences of starting the system late had resulted in some damage to the tender parts of the plant.

C. SHUTTING OFF THE IRRIGATION SYSTEM

Frost damage was reported when water was not applied continuously during times of freezing temperature. Most farmers seemed to be aware of the influence of conditions after the irrigation system is shut off, and the effect these conditions may have on the success of this method of frost control. Fifteen growers continued to irrigate until the ice was melted from the plants; 11 continued irrigating until the sun arose. Three growers irrigated until the air temperature was above 32° F.

One celery grower stopped the irrigation system when ice started to form on the plant. However, by wetting the soil and plant beforehand, he estimated that good protection was afforded to a temperature of 27° F. Another grower stopped irrigating flowers when the applied water stopped freezing, evidently when the air temperature was above 32° F. Damage was evident, but it may have been due to low temperatures or crop sensitivity.

Most growers felt that applying water until the ice was melted off was the best technique. Some growers reported severe frost damage when operation of the irrigation system was discontinued before all

the ice was melted. Several commented that the time between sunrise and ice melting is usually short and, to them, it seemed that melting all the ice was the best practice to follow.

CONCLUSIONS

Most growers feel it is difficult to separate the greater usefulness of an irrigation system for either drought or frost protection, especially with a crop such as strawberries.

This survey has pointed out a need for additional investigation of this method of frost control. The relationships between frost probability and planting time, and the effects of low temperatures and ice loads need more thorough investigation, especially in respect to high-value crops such as flowers. Growers feel that more detailed information on water application rates, minimum temperatures and design criteria are certainly necessary for the range and variety of crops needing frost protection.

SAND CHERRY (*Prunus Besseyi*) A USEFUL ORNAMENTAL DWARF HEDGE

By R. F. CARLSON

DEPARTMENT OF HORTICULTURE

FOR SEVERAL years selections of Western Sand Cherry have been tested as dwarfing rootstock for peach and plum varieties at East Lansing. In the course of these tests, observations of selected strains of the sand cherry have been made which suggest the usefulness of this plant in landscape plantings and where a dwarf ornamental hedge is desired.

DESCRIPTION OF THE SAND CHERRY

The Western Sand Cherry and selections of it have been described by Hansen and Hedrick.[1] The material here described, however, constitutes clonal selections of the sand cherry and accordingly requires special comment.

The growth-habit of this selection is bushy with branches spreading at the base and then having upright growth a few inches from the base. An occasional plant will vary from this growth-habit in being more upright, while others may exhibit a more dwarfish growth; however, proper pruning eliminates this visual difference in appearance. Plants are hardy, slow growing, but will reach 3 to 4 feet in height after 4 to 6 years.

The leaves are lanceolate, ½ to ⅝ inch wide, and 2 to 3 inches long, being a silvery gray-green in the summer and changing to various shades of red and purple in the autumn. The leaves remain on the shrubs well into November under Michigan climatic conditions. The small white flowers, ¼ to ⅜ inch in diameter, unfold in early May at the same time as the foliage is expanding. Flowers remain on the plants for 10 to 14 days. The fruit is shiny black-purple when ripe and about ½ inch in diameter. (Fig. 1). It has a tart-astringent flavor

[1]Hansen, N. E. (1911). Some New Fruits. S. Dak. Agr. Expt. Sta. Bul. 130.
Hedrick, U. P. (1915). The Cherries of New York. N. Y. Agr. Expt. Sta. 22nd Ann. Rept., Vol. 2. Part 2.

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Fig. 1. Colorful fruit and foliage of sand cherry as they appear in early September.

and is useful for preserves. The pit is relatively large in proportion to the fruit size. If not removed, fruit will remain on the bushes until after leaf-fall.

PROPAGATION OF PLANTS FOR HEDGES

The sand cherry is easily propagated from seed. Since the seed does not produce uniform seedlings, this method of propagation is not advisable for hedge material. A clonal selection is best for uniform hedge material. One or more of the following methods can be used to propagate the plant: soft-wood cuttings, hard-wood cuttings, root-cuttings, sucker plants, and layering.

Soft-wood cuttings will root in 3 to 4 weeks when taken in June and placed in sharp sand or in a mixture of peat-moss and sand (Fig. 2). The rooted cuttings can be kept in the propagation bench or in

Fig. 2. Soft-wood cuttings of sand cherry rooted in sand during the latter part of June.

the bed in the lath-house until the following spring, or they may be moved to the nursery in the fall of the same year.

Hard-wood cuttings do not root so readily as soft-wood cuttings. If the cuttings are made in the fall and calloused over winter in a nursery cellar, they will root when placed in peat moss the following spring. Root-cuttings made in the fall and treated in a similar way will produce plants the following summer.

Sucker plants from an established row of sand cherries constitute a simple and easy method of propagating the plant. Numerous sucker plants are produced during the summer which are ideal for starting new nursery rows and hedge plantings.

Layering or mounding the nursery row is also a practical method of producing new plants. To accomplish this the established nursery row of sand cherry is cut back to ground level early in March. The resulting numerous young shoots which are produced are mounded up when they are 6 to 8 inches high and then again in July. In late fall the mound is drawn away from the row and the rooted cuttings are

removed. Often roots are formed along the entire shoot that was covered with soil so that each shoot may produce two or more rooted cuttings.

LOCATION AND SOIL FOR SAND CHERRY

The sand cherry can be fitted into any landscape scene either as an individual plant, as a group, or as a hedge. In test plantings it has been used as individual group plantings, as hedges along property lines, and as foundation plantings around garages (Fig. 3). The dwarfing bushy habit of growth of the sand cherry adapts itself to various spacing distances in the hedge and in group plantings.

Sand cherry apparently grows mostly on a sandy soil in its native habitat—hence the name. The selection used in test plantings made satisfactory growth on both Hillsdale sandy loam and on Brookston clay loam. Accordingly, it seems that if satisfactory growing conditions are provided, these plants will grow well on a wide range of soil types.

Fig. 3. A 3-year-old sand cherry hedge growing on a heavy clay soil, as a foundation planting alongside a garage.

PLANTING AND PLANTING DISTANCES

A well prepared plant bed is one of the essentials for early and uniform growth of the hedge. In Michigan early spring planting seems to be most reliable. Fall planting can also be done if a mulch is provided to prevent the young plants from frost heaving.

The plantings reported here were set in the spring, 18 inches apart in the nursery row and 15 and 20 inches apart in urban plantings. Performance of these plantings as dwarf hedges indicates that for a compact hedge, a 12- to 15-inch spacing is satisfactory. If a sparse, informal hedge is desired, a 15- to 24-inch spacing is suitable. Plants spaced more than 24 inches apart will appear nearly as individual plants 2 to 3 years after planting.

PRUNING AND CARE OF THE HEDGE

To test the performance of sand cherry as hedge material, the hedges were pruned in two different ways. Some received only minor corrective pruning to shape the plants into a uniform-appearing hedge. Others were pruned more severely by shearing the top and sides into a rounded-appearing hedge. The bushy growth-habit of sand cherry lends itself to round-shaped top pruning. From the viewpoint of general appearance and dwarfness, the latter form of pruning was most satisfactory. A taller-appearing hedge can be obtained by lightly pruning the uneven shoot-growth; this is often desirable if the plants are spaced more than 24 inches apart.

The hedge should not be pruned after August 1 because flowers are borne on both new and old wood and such late pruning would remove many spring flower buds. In these tests, the hedges were pruned in early June and then again in the middle of July.

The plants respond to both mineral and organic fertilizer. Noticeable increase in growth was observed when a complete fertilizer was added to hedge rows in the nursery. These plantings also received an annual application of manure between the rows. An annual application around the plants of commercial fertilizer also would be beneficial.

Although the plants of sand cherry are resistant to drought, they will respond to some watering during dry periods. Furthermore, a light mulch of leaf mold or chopped straw will aid in conserving moisture and in providing satisfactory growing conditions.

The sand cherry is comparatively free from disease; however, an occasional plant is attacked by a "tip-blight." This usually occurs on new, succulent shoot-growth. The preventative is an application of bordeaux mixture, made when the leaves are expanding. This spray will also help to control brown-rot which is often present. All fruit should be removed from the plants in the fall.

SUMMARY

1. Selections of the sand cherry *(Prunus Besseyi)*, planted at the Horticultural Farm and at home sites, have shown promise as dwarf ornamental hedge material.

2. The hedges responded satisfactorily to various soil conditions, to nutrient and moisture conditions, and to regular pruning practice.

3. The ornamental value of this plant can be attributed to its bloom in the spring, its foliage luster in summer and fall, and its colorful and useful fruit in the fall.

THE CHERRY FRUITWORM (*Grapholitha Packardi*) AS A BLUEBERRY PEST IN MICHIGAN

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THE cherry fruitworm *(Grapholitha packardi)* has been known since the turn of the last century and seems to be generally distributed in the northern half of the United States. Newcomer (1950) reported it as being a cherry pest in western Washington. Lipman (1936) reported it as a pest on blueberries in New Jersey. Richardson (1946) considered his report to be the first on the occurrence of the pest in Iowa. Hoerner and List (1952) studied its control on cherries in Colorado, and Fluke (1951) reported it from Wisconsin. This paper contains the first record of its occurrence in Michigan[2].

It is difficult to trace early writings on this species because of its extensive synonymy. It appears under the following names in representative publications:

Epinotia pyricolana Fernald. Dyar, H. G., Checklist of North American Lepidoptera. No. 5234, 1903.

Enarmonia pyricolana Kearfott. Barnes and McDunnough: Checklist of Lepidoptera Boreal. America No. 7238, 1917.

Laspeyresia pyricolana Forbes. Heinrich, Carl. North American Moths of the Subfamilies Laspeyresiinae and Olethreutinae. U. S. Natl. Mus. Bul. 132:28, 1926.

Steganoptypcha pyricolana Murtfeldt. Bul. 23, U. S. Dept. Agr. Bul. 52, 1891.

Enarmonia packardi Fernald. Dyar, H. G., Checklist of North American Lepidoptera. No. 5282, 1903.

[1]Department of Physiology and Pharmacology, School of Medicine, University of North Dakota; employed in 1950-51 by the Department of Entomology, Michigan State College.
[2]Identification was made by J. F. Gates Clarke, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

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As the various names partly indicate, the insect infests apples, roses, cherries (cultivated and wild of various species), and concerns us primarily as a blueberry insect.

DESCRIPTION AND BIOLOGY

The adult of the cherry fruitworm is a small dark grey moth with a wing expanse of approximately ⅜ inch (0.6 to 1.1 cm). A broad transverse dark grey band across the wings distinguishes it. A strong patch of blackish sex scales on the underside of the forewings of males and on the upper surface of the hindwing is also characteristic of this species and does not occur on any other nearly related North American forms (Grapholitha and Laspeyresia) (Forbes, 1918). Because the adults usually fly only in the waning light of late afternoon, they are seldom noticed. They can be collected by means of bait pots (Marucci, 1953), but are difficult to handle and to identify afterward. The writer took them in light traps and reared them from infested twigs. The adults emerge over a 6-week period beginning—in the Grand Junction, Michigan, area—during the last week of May. Our last collection in this area was made on July 5, 1953. The record indicates that by far the greater number of adults emerge and lay eggs during the first three weeks of this period.

The opalescent eggs are about 1/50 inch (½ mm.) in diameter, somewhat flattened and often cemented in the groove between the sepals and the central disk of small blueberries. By careful examination the first eggs were found in the field on the Weymouth variety on May 27, 1953 at Grand Junction, Michigan, and on June 1, 1953 at a location 3 miles south of Covert, Michigan. The larvae hatched within a week and ate their way into the fruit through such a small hole, that detection was made extremely difficult. The newly hatched larva is about 1/12 inch (2 mm.) long and is white with a dark brown head. As the larva grows, the head, the thoracic shield, and the anal plate become smoky brown, and the body becomes a bright reddish-pink above but remains distinctly lighter on the underside. Full-grown larvae are 1/5 to 3/8 inch (5-9 mm.) long. The larvae of a related pest, oriental fruit moth *(Grapholitha molesta)* are about ½ inch long when mature. Cherry fruitworm is also characterized by its anal plate which is made up of three distinct plates which remain separate. Additional information on the larval appearance is given by Garman (1918).

A study of the location of the very small "pinprick" holes in infested berries indicates that the great majority of larvae enter the berries on the sides nearer the calyx than the stem end. Some enter the calyx next to the sepals. The cherry fruitworm differs radically in this regard from the cranberry fruitworm *(Mineola vaccinii)* which commonly enters next to the stem. While in the berry the worms occasionally make additional holes to the outside but keep only one opening, covering the others with silk spun from side to side in the opening. The larvae of cherry fruitworm leave the berries sooner than do those of the cranberry fruitworm. In a survey made on July 8, 1953 near Fruitport, Michigan, where the cherry fruitworm was abundant, 207 blueberries with evident insect damage were examined. Only 1 still contained a larva of cherry fruitworm, but 16 contained green fruitworms, of which 13 were the cranberry fruitworm. Observation of the holes made in the berries revealed the absence of frass, which is almost certain evidence of cherry fruitworm infestation. Abundant frass is characteristic of cranberry fruitworm. When moving from one berry into the next both species spin the berries together.

Blueberry harvest begins about July 1. Toward the end of June and in the first part of July the worms leave the berries and find a suitable place to hibernate. Berries injured as a result of feeding by cherry fruitworm are picked together with the uninjured ones. The larvae do not leave the bushes as do the cranberry fruitworms, but wander about and commonly enter the pith of pruned twigs into which they may tunnel as much as 2 inches, but usually less. The opening in the end is closed smoothly and tightly with silk so that it normally escapes observation. They also encase themselves in cracks of the bark lower down on the bushes or even in plain sight on the outside of twigs. However, the silky covering with which they cover themselves is so nearly the same color as the bark that they are hard to detect. Here they remain all summer, fall and winter to pupate early the next May. Of several worms found inside twigs on April 21, none had pupated. For the grower the significant fact is that the moth carries the pupal case out of the place of hibernation and lets it protrude more than half way from the opening of its hiding place. After the moth has left, the honey-colored translucent pupal cases can be seen readily, particularly when they protrude from the center of a pruned stub. Carefully looking for their first appearance is the key to good control. The first insecticide dust should be applied immediately after the spent pupae are found.

CONTROL

Hoerner and List (1952) recently made a 3-year study of control of this worm on cherries and examined more than a million fruits. Ten insecticides were used. Beginning with toxaphene which was least effective, rotenone, lead arsenate, chlordane, synergized rotenone, nicotine, and TDE (DDD) were more and more effective but did not control the pest as effectively as three others—DDT, methoxychlor, and parathion—with three applications during the period when moths were laying eggs. However, unless the infestation is known to be very serious three airplane applications of 40 pounds of 5 percent methoxychlor dust per acre are best.

SANITARY MEASURES

It is important to remove all prunings from the field and to burn them before the middle of May. Some growers have been in the habit of pushing all brush by means of a tractor to the end of the rows, where it accumulates for several years. In such fields the infestation has been found to be much higher near the brush piles than at the other end of the fields. Since the cherry fruitworm infests apples, several species of wild cherries, cultivated cherries and roses, the brush piles should not be near blueberry fields or they should be disposed of regularly.

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THE VALUE OF SAFFLOWER AS A WILDLIFE FOOD PLANT IN MICHIGAN

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SAFFLOWER (*Carthamus tinctorius* L.), a member of the Compositae family, has been grown for many years as an oil-seed crop and as a red dye source in India and Egypt.[1] Experimental tests during the past 25 years have shown that this plant is well adapted to various areas of the western United States for the production of oil-seed crops. Investigators in the West have also noted that the plant has a value as a wildlife food. Claassen and Hoffman[2] state that pheasants are fond of the seed of safflower and that this plant should have some value as a source of food for pheasants and other game birds during the winter months in the Great Plains area. In northern Idaho, Hungerford[3] found safflower to be a good winter game food. The plants in that area remain intact during the winter and are palatable to pheasants and partridge. Field trials during 1950-52 indicated that safflower will grow in Minnesota, although the yields were not sufficient for it to be considered as an economic crop. Also, the oil content of the seed was only about half that of seed of the same varieties grown in Nebraska.[4]

DESCRIPTION OF THE MICHIGAN EXPERIMENTS

Observations and measurements were made of plantings of safflower in three experimental areas for three years to determine its value for wildlife in southern Michigan. Experimental plots were located in the Fred Russ Forest area near Dowagiac, in the W. K. Kellogg Con-

[1]Rabak, F. (1935). Safflower, as possible new oil-seed crop for the northern Great Plains and the far western states. U. S. Dept. of Agri. Circ. 366.

[2]Claassen, C. E. and A. Hoffman (1950). Safflower production in the western part of the northern Great Plains. Univ. of Neb. Agri. Expt. Sta. Circ. 87 (revised).

[3]Hungerford, K. E. (1948). Safflower as a winter game bird food. Jour. Wildlife Mgt. 12 (4): 436-437.

[4]Myers, W. M.; E. R. Ausemus, J. O. Culbertson, E. H. Rinke, J. W. Lambert, H. L. Thomas, E. L. Pinnell, L. J. Elling, R. G. Robinson, K. S. Koo, K. J. Hsu and D. W. Sunderman (1953). Varietal trials of farm crops. Univ. Minn. Agri. Expt. Sta. Misc. Rpt. 18.

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servation Area near Augusta,[5] and at Michigan State College, East Lansing, from 1951 to 1953. Soils in the plot areas had a sandy loam surface over a heavier subsurface soil, with varying amounts of clay from 17 to 38 inches below the surface. The plots at East Lansing and in the Russ Forest area were on flat land, and those in the Kellogg Area were in a small flat valley between two relatively steep slopes.

Approximately equal samples of seed weighing 2⅔ ounces of each of four varieties, N-3, N-6, N-8, and N-852,[6] were sown in May or early June in rows from 24 inches to 36 inches apart at the rate of 7 to 10 seeds per foot of row. In addition, a few plots were seeded by hand broadcasting. All plots were weeded twice each year except those in the Kellogg area in 1953 which were weeded only once.

RESULTS

PLANT CHARACTERISTICS

Plant Survival—The number of plants produced per foot of row differed according to varieties. The survival of varieties N-8 and N-6 was classified as good; the average number of plants was generally 3 to 6 per foot of row. The survival of varieties N-852 and N-3 was classified as fair; the number of plants generally averaged from ½ to 2 per foot of row.

Plant Height—Most of the plants regardless of variety were from 12 to 17 inches high; the range in height was from 8 to 27 inches. Height growth sometimes varied with the site and season. In the Kellogg Area in 1953 all plants of three varieties, N-3, N-6, and N-8, averaged 23 inches in height whereas plants in other plots during that season averaged 12 inches in height.

Seed Production—The total production of seed depends upon the number of fruiting heads per plant, their size, and the number of seeds per head. Most plants in the test areas had from 2 to 5 fruiting heads averaging about ¾ inch in diameter. Large fruiting heads, 1 inch to 1¼ inch in diameter, had from 30 to 60 seeds; smaller heads, from ¼ to ½ inch in diameter, had from none to 20 seeds. The fruiting heads of varieties N-6, and N-8 were the largest in the three test areas.

It was noted that seeds were not produced in all heads and that some were not completely developed and would be of little value as

[5]Planting, weeding, and some observations were under the direction of W. Lemmien at the W. K. Kellogg Conservation Area and C. Ingersoll Arnold at the Fred Russ Forest.

[6]These are the commercial varieties of safflower eligible for certification. They were supplied by the Department of Chemurgy, University of Nebraska, Lincoln.

a wildlife food. In 1951, only the plots at East Lansing had plants with a relatively high percentage of fully developed seed. In 1952 seed development was poor in all three test areas, whereas in 1953 it was relatively good. During 1953, approximately 50 to 100 percent of the seeds in the larger heads matured and from 10 to 60 percent in the small heads. The N-6 and N-8 varieties were the most productive in all areas.

Winter Condition—During the winter and early spring following each of the growing seasons, most of the plants of variety N-6 remained in a normal growing position with seeds in the heads. Plants of varieties N-8 and N-852 were also upright so that seeds were available above the snow during two of the three seasons whereas plants of variety N-3 remained intact during only one of three seasons.

FEEDING EXPERIMENTS

Safflower seed from plants grown in 1951 was fed to penned pheasants by staff members of the Rose Lake Wildlife Experiment Station. They reported that the pheasants ate all varieties of safflower given to them with their regular corn feed.

FACTORS AFFECTING PLANT DEVELOPMENT

SOIL

Within some plots there were noticeable variations in growth that appeared to be due to differences in the soil, possibly variations in the depth and character of the B horizon. The relatively large plants of the plots at Kellogg Conservation Area might have been a response to good moisture or fertility conditions resulting from the position of the plots in a valley bottom and the presence of a definite heavy B layer.

COMPETITION

When competition with weeds was severe the safflower plants either died or were low in vigor. Two of the plots in 1951 were failures because of weed competition. Low vigor plants also resulted from close spacing. Three or four plants per foot of row appears to be optimum.

SUMMARY AND CONCLUSIONS

Four varieties of safflower, N-3, N-6, N-8, and N-825, were tested in three locations over a 3-year period under southern Michigan conditions. Two varieties, N-6, and N-8, showed the most promise as winter food for wildlife. Plant development was noticeably affected by weed competition and also seemed to be influenced by differences in subsoil texture. Further testing on various soil types and at different levels of fertility will be necessary before varieties of safflower can be recommended for planting in wildlife food patches.

HYDRACOOLING AND TRANSPORTING RED CHERRIES IN WATER[1]

A Progress Report

By J. H. LEVIN[2] and H. P. GASTON[3]

THE PRODUCTION of red cherries in Michigan has been increasing steadily for more than 30 years. There are indications that this trend is likely to continue for some time. Production is also increasing in most of the other states that sell in the markets to which Michigan cherries go. This probably means that production, processing and marketing of red cherries are likely to become even more highly competitive than they are at the present time.

If packers are to sell the tonnages that are in prospect, at prices that will return a profit to themselves and to the growers who supply them, they must put up a quality pack at minimum cost.

One operation involved in procuring cherries for processing that could be improved is that of assembling and transporting the fruit to the processing plant.

The method now commonly employed requires a large investment in lugs, a considerable number of which must be repaired or replaced annually. Moving the fruit in lugs involves much costly time consuming labor. Keeping growers supplied with empties presents difficult problems in both transportation and accounting.

The industry needs a handling method that will reduce costs, relieve congestion and make it easier to maintain on-the-tree quality. The study here reported was undertaken for the purpose of determining whether transporting cherries in water would accomplish these ends.

[1]Based on work carried out jointly by the Mechanical Processing Section, A. R. S., Agricultural Engineering Research Branch, U. S. Department of Agriculture; the Departments of Agricultural Engineering and Horticulture, Michigan State College, East Lansing; and Michigan Fruit Canners, Inc., Benton Harbor, Fennville, and South Haven, Michigan. Special credit is due Mr. Ray Floate, horticulturist, Michigan Fruit Canners, who ably represented his organization throughout the experiments.

[2]Agricultural Engineer, Agricultural Engineering Research Branch, U. S. Department of Agriculture.

[3]Department of Horticulture, Michigan State College.

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METHOD

EQUIPMENT

A single-axle trailer was equipped with three, 11-gage sheet metal tanks measuring 4 feet by 7 feet, 8 inches by 5 feet. The tanks were provided with a system of pipes and valves that made it possible to introduce water near the bottom. Each tank was provided with a baffle, to help reduce shifting of the load, an overflow opening near the top, and a 6-inch outlet (provided with a gate valve) near the bottom.

Each tank had a capacity of approximately 6,500 pounds of cherries and a sufficient amount of water (about 1,500 pounds) to cushion the fruit during transit. The tank trailer had a total capacity of approximately 19,500 pounds of cherries.

The receiving stations at which the tanks were loaded were equipped to provide a minimum of 20 gallons of cold (55° F. or below) water per minute. It was necessary for each of the stations to provide also a means of disposing of the water used in cooling the fruit.

The processing plant at which the cherries were unloaded was

Fig. 1. The tank truck used in the experiments.

equipped with a movable flume through which the fruit was moved from the tank trailer to the receiving hopper. To flume the cherries out of the tank truck, a water supply of at least 30 gallons per minute was also necessary.

PROCEDURE

The first step in preparing a load of cherries for transportation in water was to fill the tanks with cold water. When the loads of fruit that were to be included in the trials arrived at the receiving station, they were divided into two lots of approximately the same size. The cherries in one of these lots were poured from the lugs into the tanks containing the cold water. While the tanks were being filled with cherries the water was turned on and allowed to circulate through the fruit and over-run at the top. The water that overflowed carried away a considerable amount of dirt, leaves, and stems.

When the tanks had been filled to the proper level with fruit and the contents cooled to a temperature between 55 and 60 F., the intake valve was closed and the hose disconnected. The water level in the tanks was then lowered to a point about 5 inches below the top level of the fruit. The "tanker" was then started on its way to the processing plant. Upon arrival, the fruit was flumed into the receiving hopper and moved from there to designated soak tanks and later processed in the normal manner.

While the fruit in one of the lots mentioned above was being poured into the tanks, other lugs from the same lot were loaded on the truck used to haul the "check" loads. The check truck was dispatched to the processing plant as soon as the load was completed. Upon arrival, the cherries were unloaded in the conventional manner and moved into soak tanks reserved for the purpose. After a normal soak period they were processed in the usual way.

RECORDS

Data on water temperature, brix readings, grade, percent scald and the number of cherries per pound were taken 1) at the receiving station, 2) when the loads arrived at the processing plant and 3) again after the fruit had been soaked. After the experimental lots were processed, sample cans were coded and set aside. The cans were "cut" at a later date and a record made of the "score" and drained weight of the fruit. Records were also kept on the number of man hours required to load and unload all of the fruit included in the trials.

Data were taken on 21 loads (398,108 pounds) of cherries moved in tanks and an equal number of loads (439,462 pounds) handled in lugs.

RESULTS

LOADING

The labor required to pour the fruit from lugs into tanks at the receiving station was about the same as that needed to transfer the lugs from the growers' trucks to the ones used in moving the fruit from the receiving station to the processing plant.

DURING TRANSIT

The temperature of the fruit and water, moved in the tanker, did not rise during transit. At temperatures of 60° F. or below, the amount of heat resulting from respiration is relatively small. The evaporation of the water from the surface of the load, as the air moved across the open tanks, was sufficient to remove the small amount of heat generated.

When the water level in the tanks was maintained below the upper surface of the cherries, there was no spillage or objectionable shifting of the load during transit. Using an excessive amount of water, however, was found to cause undesirable sloshing.

UNLOADING

The check lots, made up of cherries moved in lugs, were unloaded and moved with fork-lift trucks. A crew of seven men was employed to unload, dump the fruit from the lugs, and re-load the empties. They handled the cherries at the rate of approximately 45,000 pounds per hour. This amounted to about 6,450 pounds of fruit per man hour.

Only two men were required to flume the cherries out of the tanks (Fig. 2). In this case, the fruit was discharged at the rate of about 25,000 pounds per hour or 12,500 pounds per man-hour.

QUALITY

Data on brix readings, grade, lug scald, size, score and drained weight of the fruit after processing appears in Tables 1 to 5. The figures recorded in the tables are based on data taken on the 42 loads included in the trials.

Fig. 2. Cherries being flumed out of the tank truck at the processing plant.

The data in Table 1 shows that, on the average, the total reduction in the percentage of soluble solids that occurred during transportation and soak, in the water moved cherries was slightly greater (0.20) than in the lug-hauled fruit. Whether this change is considered an asset or a liability depends upon the interpretation of the individual packer.

*TABLE 1—Refractometer readings**

Method of handling	At receiving station	At processing plant		After soaking		
	Brix	Brix	Change from Prev. Read.	Brix	Change from Prev. Read.	Change from Initial Read.
Water hauled	15.50	14.60	−0.90	14.55	−0.05	−0.95
Lug hauled	15.50	15.55	+0.05	14.75	−0.80	−0.75

*The readings were taken on the mixture resulting when random samples of 50 or more cherries were processed in a Waring blender.

The data in Table 2 show that the grade of lug-hauled cherries went down during transit 1.45 percent as compared with 0.04 percent when the fruit was transported in water. The relatively small difference in grade can be made up by picking out a greater percentage of the defective cherries from the lug-hauled fruit during the sorting which precedes processing.

*TABLE 2—Grade of cherries**

Method of handling	At receiving station	At processing plant		After soaking		
	Grade	Grade	Change from Prev. Read.	Grade	Change from Prev. Read.	Change from Initial Read.
Water hauled	92	91.31	−0.69	91.96	+0.65	−0.04
Lug hauled	92	90.65	−1.35	90.55	−0.1	−1.45

*Federal-state standards were used in determining grades. The work was done by the investigators under the supervision of federal-state inspectors.

That scald was considerably more prevalent in the lug-hauled fruit than in the water-transported cherries is shown in Table 3. Some of the scald found in cherries tends to disappear when the fruit is hot packed. Inasmuch as an ever-increasing percentage of the pack is frozen, any method of handling that helps keep these defects at a minimum is to be desired.

*TABLE 3—Percentage of fruit showing scald**

Method of handling	At receiving station	At processing plant		After soaking		
	Percent	Per-cent	Change from Prev. Read.	Per-cent	Change from Prev. Read.	Change from Initial Read.
Water hauled	5	9.55	+4.55	15.55	+6.00	+10.55
Lug hauled	5	16.50	+11.50	23.30	+6.80	+18.30

*A brownish discoloration of the skins, which is thought to be caused by heat and pressure, and, which in advanced stages, causes the flesh of the fruit to deteriorate.

The data in Table 4 show that during transit water-hauled cherries increased in weight whereas the lug-moved fruit lost weight. While being soaked at the processing plant the water-hauled cherries remained about the same in weight while the lug-moved fruit increased in weight. Both types of fruit lost approximately the same amount of weight during the pitting process. The net result was that the lug-hauled cherries weighed less after pitting than did the water-hauled fruit.

*TABLE 4—Weight per cherry**

Method of handling	At receiving station	At processing plant		After soaking		After pitting		
	Grams	Grams	Change from Prev. Read.	Grams	Change from Prev. Read.	Grams	Change from Prev. Read.	Change from initial Read.
Water hauled	3.77	4.04	+0.27	4.00	−0.04	3.26	−0.74	−0.51
Lug hauled	3.77	3.72	−0.05	3.79	+0.07	3.07	−0.72	−0.70

*Figures were obtained by counting the number of cherries per pound and converting the figures to grams per cherry.

Data in Table 5 were obtained by a federal inspector who cut and scored the sample cans several months after processing. The figures show that there was a slight differential in favor of the water-hauled fruit. All samples in both lots met legal requirements for drained weight and score for U. S. grade-A pack.

TABLE 5—After canning

Method of handling	Drained weight differential from check expressed in percent	Average score differential from check
Water hauled	−1.11	+0.84
Lug hauled "check"	0.00	0.00

COMMENTS

When conventional methods and equipment are used, about 10 tons of cherries are hauled on a single-axle trailer. The single-axle tank truck used in the trials had a capacity of more than 9 tons of fruit, which means that the lugs and pallets used in the conventional method weighed almost as much as did the tank and water used in the experimental method. This indicates that the cost of moving the fruit from receiving station to processing plant should be about the same for both methods. It should also be noted that while lugs and pallets must be moved both to and from the plant, the water used to cushion the fruit need be hauled only once.

Approximately 750 lugs were required to hold the tonnage of cherries moved in the tanker. Ordinarily, the processor must make available from two to three lugs for every lug of cherries that a given grower harvests in a single day. This means that the tank truck used in the trials replaced from 1,200 to 1,500 lugs. At present prices, 1,200 lugs cost about $600, but the tank which replaced them cost considerably less, and will probably last much longer.

While the equipment used and the methods employed in the trials proved to be reasonably satisfactory, both could undoubtedly be perfected. The design of the tanks, for example, could be improved and some of the steps involved in getting the cherries out of the tanks and into the soak vats could probably be eliminated.

CONCLUSIONS

1. Cherries moved in water lose less weight in transit, show less scald, require less pick out in sorting than cherries moved in lugs.
2. Cherries that are moved in water can be unloaded more rapidly and with less labor than those hauled in lugs.
3. The use of tank trucks will make it possible to effect considerable savings in the total number of lugs required to service growers whose cherries are moved in tanks.

MICHIGAN 570—A NEW CORN HYBRID[1]

By E. C. ROSSMAN
DEPARTMENT OF FARM CROPS

MICHIGAN 570, a new "110-day" relative maturity corn hybrid, has been released by the Michigan Agricultural Experiment Station for certified seed production this year. Certified seed will be available for planting by farmers in 1955.

Five acres of double-cross seed for Michigan 570 were produced in 1953 to provide seed for farm demonstration trials in 1954. Michigan farmers will have an opportunity to see this new corn hybrid and to get acquainted with it in 1954.

ORIGIN OF MICHIGAN 570

Michigan 570 was developed as a result of the cooperative hybrid corn testing program of the North Central States Hybrid Corn Conference. This conference is composed of corn breeders of the agricultural experiment stations in Michigan, Wisconsin, Minnesota, Ohio, Illinois, Indiana, Iowa, Kansas, Missouri, Nebraska, South Dakota and North Dakota, and the United States Department of Agriculture.

Promising new inbred lines from each of these stations are exchanged and evaluated in nurseries at each of the agricultural experiment stations. The best of the new inbred lines, together with older well-established inbreds, are then crossed in all possible single-cross hybrid combinations. Yield trials of these single-cross hybrids are conducted at each station interested in the particular maturity group. From the results of these single-cross tests, the performance of the double-cross hybrids can be predicted very accurately. Each station can make and test any of the double-cross hybrid combinations that it wishes.

In 1947, 10 inbred lines from several stations were combined in all possible 45 single-cross hybrids. They were yield-tested in five

[1]A grant from the Michigan Certified Hybrid Seed Corn Producers' Association helped to finance this study.

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TABLE 1—Performance of Michigan 570 in comparison with other certified hybrids during the 4-year period 1950-53 and the 4-year average performance

Hybrid	Year	Number of trials	Yield in bushels per acre	Moisture in ears, percent	Stalk lodging, percent	Root lodging, percent	Days to 50% silked*
Michigan 570....	1950	11	88.4	33.1	4.6	7.1	83
Michigan 480....	1950	11	81.5	31.3	3.6	3.9	83
Ohio M15.....	1950	11	71.2	30.9	6.4	10.1	83
Michigan 350....	1950	11	76.9	24.6	6.5	5.7	79
Michigan 29D...	1950	11	77.6	33.7	3.9	5.4	83
Michigan 570....	1950	4	88.3	31.2	6.0	6.8	83
Michigan 20D...	1950	4	81.8	31.5	4.0	4.9	82
Michigan 570....	1951	12	76.7	39.2	2.1	8.9	83
Michigan 480....	1951	12	79.6	37.2	2.8	4.2	81
Ohio M15.....	1951	12	71.4	34.5	5.4	7.2	79
Michigan 350....	1951	12	76.6	32.0	2.2	4.0	76
Michigan 29D...	1951	12	76.7	36.7	2.4	4.1	82
Michigan 570....	1951	2	90.1	34.8	2.8	0.0	83
Michigan 20D...	1951	2	87.6	33.1	2.3	0.0	82
Michigan 570....	1952	15	102.8	29.1	1.5	0.0	83
Michigan 480....	1952	15	98.4	26.2	1.4	0.0	81
Michigan 350....	1952	15	89.1	22.4	2.2	0.0	77
Ohio M15.....	1952	15	85.2	25.7	2.1	0.0	80
Michigan 29D...	1952	15	91.4	27.1	1.8	0.0	81
Michigan 20D...	1952	15	97.0	27.3	0.7	0.0	81
Michigan 570....	1953	13	95.4	27.7	3.4	0.0	73
Michigan 480....	1953	13	93.0	25.0	5.4	0.0	72
Ohio M15.....	1953	13	81.5	24.6	5.7	0.0	71
Michigan 350....	1953	13	80.8	21.0	3.8	0.0	68
Michigan 29D...	1953	13	83.3	27.3	3.7	0.0	72
Michigan 20D...	1953	13	83.7	26.5	3.5	0.0	73
Michigan 570....	4-yr. av.	51	91.7	31.9	2.8	3.7	80
Michigan 480....	4-yr. av.	51	89.0	29.6	3.2	1.9	79
Ohio M15.....	4-yr. av.	51	78.0	28.6	4.7	3.9	78
Michigan 350....	4-yr. av.	51	81.4	24.8	3.5	2.2	75
Michigan 29D...	4-yr. av.	51	82.9	30.8	2.5	2.2	79
Michigan 570....	4-yr. av.	34	97.6	29.1	0.4	0.9	79
Michigan 20D...	4-yr. av.	34	89.6	27.9	0.8	0.6	79

*Data on number of days from planting to 50 percent silking obtained only from Ingham County trials.

states in 1948. The performance of all possible 630 double-cross hybrids was predicted from the single-cross data. Double-cross seed of a number of these hybrids was produced in 1949 and tested in over-state trials in Michigan during 1950, 1951, 1952, and 1953. The

performance of one of these experimental hybrids, Experimental 486 (CB8501), was superior to the others in Michigan tests and has been released as Michigan 570.

The pedigree of Michigan 570 is (M14 x Oh43) x (L289 x Oh5). The inbred line, M14, is an old, well-established inbred developed by Ben Moews of the Moews Seed Co. of Illinois. Oh43 and Oh5 are two new inbreds developed by Dr. G. H. Stringfield at the Ohio Agricultural Experiment Station. L289 is an old, well-established inbred developed by Dr. M. T. Jenkins while he was at the Iowa Agricultural Experiment Station.

CHARACTERISTICS OF MICHIGAN 570

Michigan 570 is rated as a 110-day relative maturity hybrid and is widely adapted for grain and silage production in the southern part of the state. In southern Michigan over-state hybrid corn trials[2] no other hybrid has a higher yield record and it has matured in all of the trials to date.

There are many places throughout central Michigan where other hybrids similar in maturity to 570 are successfully grown. Performance records of 570 in central Michigan over-state corn tests show that it is outstanding as a high-yielding, mid-season to late-maturing corn. It cannot be expected to mature under all conditions in central Michigan, particularly when killing frosts occur earlier than normal and in seasons when corn matures slowly. It did not reach full maturity in the 1950 and 1951 trials in Newaygo County and in the 1951 Ingham County trials, but it has matured in all of the other central and southern Michigan trials.

Table 1 presents the average performance by years for each of the four years of the over-state tests conducted in Monroe, Kalamazoo, VanBuren, Kent, Eaton, Ingham, Oakland, Saginaw, Tuscola, Gratiot, and Newaygo Counties. Yields are reported as bushels of shelled corn at 15.5 percent moisture; moisture content is given as the percentage of moisture in the ear (cob plus grain); stalk lodging refers to the percentage of plants broken over below the ear; and root lodging is the percentage of plants leaning at an angle of 30 degrees or more from the vertical.

[2]Rossman, E. C. (1953). Corn Hybrids Compared. Mich. Coop. Ext. Folder F-67 (revised).

TABLE 2—Comparisons of several certified hybrids. The numbers in columns 3-6 refer to the number of trials in which the particular hybrid excelled the other hybrid with which it is compared

Hybrid	Number of trials	Higher yielding	Drier in moisture	Less stalk lodging	Less root lodging
(1)	(2)	(3)	(4)	(5)	(6)
Michigan 570.....	51	30	6	20	3
Michigan 480.....	51	17	40	15	8
Equal.....	..	4	5	16	1
Michigan 570.....	51	46	2	39	7
Ohio M15.....	51	5	48	6	5
Equal.....	..	..	1	6	1
Michigan 570.....	51	48	0	24	2
Michigan 350.....	51	3	51	16	3
Equal.....	..	..	..	11	1
Michigan 570.....	51	40	15	17	9
Michigan 29D.....	51	8	32	19	4
Equal.....	..	3	4	15	0
Michigan 570.....	34	26	8	11	4
Michigan 20D.....	34	7	21	17	7
Equal.....	..	1	5	6	0

Michigan 570 has averaged 13, 18, 9, 11, and 3 percent more corn per acre than Michigan 350 (90-day maturity), Ohio M15 (100-day), Michigan 20D (110-day), Michigan 29D (110-day), and Michigan 480 (105-day), respectively. Paired comparisons of Michigan 570 with five other Michigan certified hybrids are presented in Table 2, which shows the number of times that one hybrid excelled another in each of four characteristics. It has yielded more than 350 in 48 out of 51 trials, more than M15 in 46 out of 51 trials, more than 20D in 26 out of 34 trials, more than 29D in 40 out of 51 trials, and more than 480 in 30 out of 51 comparisons.

Lodging resistance of Michigan 570 is very good. Tests with mechanical corn pickers have shown that 570 is well adapted to clean mechanical harvest. Color and conformation of plants and ears are very attractive. It has good "eye appeal." The plants do not grow so tall as those of Michigan 480, and the ears are borne lower on the stalk. Ears are long, slightly tapered at the end, deep yellow in color, with a slender cob that gives good shelling percentage.

SEED PRODUCTION

In order to qualify for recommendation and release by the Michigan Agricultural Experiment Station, a new corn hybrid must have been tested for at least 3 years in over-state trials in Michigan. It must be superior to the present Michigan certified hybrids of comparable maturity in some important agronomic characteristic.

When a new corn hybrid has been approved, seed of the parent inbred lines is released to the Michigan Foundation Seed Association. This organization maintains the inbred lines and also produces the single-cross foundation seed used by the certified seed grower to produce the commercial double-cross hybrid seed corn. Certified seed is produced under inspection of the Michigan Crop Improvement Association.

(M14 x Oh43) is used as the seed parent and (L289 x Oh5) is used as the pollen parent. Silking and pollen shedding of the two parents match well so that both can be planted at the same time. No difficulty has been experienced in detasseling the seed parent. The seed grades a high percentage of large and medium flats having a good appearance.

Michigan 250 (85-day relative maturity) and Michigan 350 (90-day maturity) were released in 1951.[3] The pedigrees are (Oh51 x R53) x (W10 x MS206) and (W23 x MS24) x (W10 x MS206), respectively. Michigan 480 (105-day maturity) was released in 1952.[4] Its pedigree is (W23 x Oh51A) x (W10 x Oh40B).

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[3]Rossman, E. C.; E. E. Down, and R. E. Decker (1952). Michigan 350 and Michigan 250: Two New Hybrids for Michigan. Mich. Agr. Expt. Sta. Quart. Bul. 34: 201-209.

[4]Rossman, E. C. (1953). Michigan 480—A New Corn Hybrid. Mich. Agr. Expt. Sta. Quart. Bul. 35: 288-293.

THE FEEDING VALUE OF RED CLOVER CONSERVED AS HAY AND AS SILAGE IN RESPECT TO MILK PRODUCTION

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FORAGE CROPS furnish feed nutrients at a lower cost than grains. The method of conserving these crops to the best advantage is important in most areas because of the unfavorable hay-curing weather which usually prevails during the most desirable time for conserving first-cutting hay. In only a few experiments have hay and hay-crop silage been compared when the hay and silage were cut at the same time and from the same field.

Probably the first comparison of the relative feeding value of clover hay and silage was made by Clark (1913). Three different experiments were carried out in which 32 to 45 pounds of clover silage were compared with clover hay. Timothy hay and a grain mixture were fed throughout. The results indicated that there was no significant difference between clover hay and silage from the viewpoint of milk and fat production. Bechdel (1923) made hay and silage from a crop consisting of one-third timothy and two-thirds red clover which was in full-bloom. The silage contained 67 percent moisture. The hay and silage were compared by feeding two groups of milking cows in a 4-week reversal experiment. Bechdel concluded that the clover silage was superior to the hay when adequate grain was fed with both rations.

Horwood and Wells (1936) used six cows in a double reversal experiment to compare alfalfa hay with alfalfa silage which had been cut at the same time and from the same field. The silage was preserved with molasses. The cows produced about 3 percent more milk while receiving silage. Shepherd *et al.* (1947) compared alfalfa conserved as silage, barn-cured hay, and field-cured hay for milk production and found no significant difference between these three

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roughages. The milk production per acre, however, when calculated from the amount of dry matter conserved, was greater when silage was fed than when either barn-cured or field-cured hay was used. Similar results were reported by Turk *et al.* (1951). Little *et al.* (1953) reported no significant difference in the feeding value for milking cows between field-cured hay and silage made from the same field and harvested at the same time.

The purpose of this investigation was to compare the feeding value of red clover conserved as hay and as silage for milk production both from the viewpoint of the unidentified lactation factor(s) found in grain and also the unidentified lactation factor(s) which forage crops sometimes manifest even when ample grain is in the ration.

EXPERIMENTAL

A field containing a mixture of 90 percent red clover in three-fourths bloom, 5 percent timothy with the heads just coming out of the boot and 5 percent brome in the bud-stage was mowed and raked on June 15. Alternate windrows were chopped with a field chopper and blown into a tower silo after 3 to 4 hours of wilting. The temperature and relative humidity during the wilting-period averaged about 78° F. and 80 percent, respectively. A shower in the afternoon interrupted filling until the morning of June 16. About 50 pounds of a commercial dried-molasses mixture were added per ton of silage as a preservative. The windrow left for hay received very light showers on June 18, 20 and 21. The hay was turned on the morning of June 22, baled and hauled to the barn in the afternoon. During the period of June 15 to June 22, the average mean daily temperature varied from 54° to 74° F. and the relative humidity varied from 38 to 92 percent. The mean temperature during the afternoon of June 22 was 80° F. and the humidity was 45 percent. The hay was graded U. S. No. 1 on color and leaf.

The coefficients of digestibility of the clover conserved as hay and as silage were determined by using two cows for each type of feed. The coefficients for the hay were determined on the basis of a ration of hay alone. It was necessary, however, to supplement the silage ration with corn in order to get the total digestible nutrient intake to meet the requirements. The coefficients of digestibility reported by Morrison (1948) were used for the corn and the young bromegrass hay. The requirements used for digestible protein and total digestible nutrients were those recommended by the National Research Council (1950).

TABLE 1—The chemical composition, coefficients of digestibility, digestible protein, and the total digestible nutrient content of the feeds

	D.M.*	Ash	Protein	Ether Ext.	Crude fiber	N.F.E.*	Dig. Prot.*	T.D.N.*
	%	%	%	%	%	%	%	%
Clover								
(as cut)	18.7	1.41	3.06	0.63	4.84	8.76	....	....
	100.0	7.5	16.4	3.37	25.9	46.8	....	....
(as put in silo)	25.6	1.78	4.18	0.61	6.47	12.56	....	....
	100.0	7.0	16.3	2.38	25.3	49.1	....	....
(fed as silage)	27.5	2.28	4.82	1.33	7.34	11.73	2.6	16.4
	100.0	8.3	14.5	4.84	26.7	42.7	9.5	59.6
Coef. of digest	62.0	....	54.0	65.0	65.0	70.0	....	....
(fed as hay)	87.2	5.84	12.9	1.78	27.0	39.7	8.1	53.6
	100.0	6.7	14.8	2.04	31.0	45.5	9.3	61.5
Coef. of digest	64.0	....	63.0	39.0	63.0	70.0	....	....
Brome hay bud	90.0	6.44	11.0	2.61	27.4	42.6	6.4	54.1
Coef. of digest†	....	....	58.0	24.0	68.0	65.0	....	....
Corn (U. S. No. 2)	86.1	2.86	11.8	4.04	2.5	64.9	9.1	79.5
Coef. of digest†	....	....	77.0	90.0	57.0	93.0	....	....
Molasses (dry mix)	89.9	15.8	14.9	2.10	6.5	50.6	8.0‡	55.0‡

*Key to abbreviations:
D.M. = Dry matter
N.F.E. = Nitrogen-free extract
Dig. Prot. = Digestible protein
T.D.N. = Total digestible nutrients
†Morrison's coefficients.
‡Estimated coefficients.

The dried molasses was a commercial product consisting of cane molasses, distillers' solubles, rice bran, corn gluten meal and iron oxide. The digestible protein and total digestible nutrient values recorded in Table 1 were estimated from the protein, crude fiber and nitrogen-free extract content. Each pound of silage contained about 0.025 pound of dried molasses. A cow consuming 80 pounds of the silage would get about 2 pounds of dried molasses daily.

Eight Holstein cows were used in a double-reversal type of experiment for 30-day periods to determine whether the hay or the silage contained the most of the unidentified milk-stimulating factor(s) sometimes observed in hay even when grain is present in the ration. Owing to the limited number of milking cows in the Dairy Experimental Herd which were available for this type of work, it was necessary to use cows at varying levels of milk production, stages of lactation and gestation. In this type of study, it is necessary to keep the levels of roughage and grain constant for each individual cow.

The effect of clover hay and silage on the milk production of five depleted cows was also determined. Dried molasses was substituted for an equivalent amount of hay in three trials, but no other grain was used in this phase of the study.

The silage used in this experiment had been conserved for 7 months in order to determine its quality. High-moisture silage may be of good quality up to 3 months after ensiling and be of poor quality by mid-winter. This is the case especially when no preservative is used. The clover silage which was fed during February, March and April had a pleasant aroma. The pH varied from 3.90 to 4.03.

RESULTS

The chemical composition, coefficients of digestibility, digestible protein and the total digestible nutrient content of the feeds used in the experiment are shown in Table 1. The increase in the dry matter content of the silage from 25.6 percent at the time of filling to 27.5 percent when fed was probably due to seepage from the silo. The hay and silage contained about the same amount of protein and crude fiber, when compared on the dry basis. The silage contained 4.84 percent ether extract, while the hay contained 2.04 percent ether extract on the dry basis. The higher value obtained for the silage was probably due to the presence of some end-products of fermentation. In calculating the total digestible nutrient content of both hay and silage, the ether extract value was added without multiplying by 2.25. The coefficients of digestibility for the dry matter, crude fiber and nitrogen-free extract of the hay and silage were in good agreement. The protein coefficient was somewhat higher for the hay than for the silage, whereas the reverse was true for ether extract. There was no significant difference between the hay and silage in respect to the digestible protein and total digestible nutrients on the dry basis. The carotene content of the silage and hay was 160 and 19 micrograms per gram of dry matter, respectively.

A comparison of the results of the 30-day double-reversal trials recorded by 15-day periods is presented in Tables 2 and 3. An equal amount of corn was fed with the hay or silage in each trial. The cows listed in Table 2 received hay during the first and third periods, whereas the cows listed in Table 3 received silage during the first and third periods. Both groups were started simultaneously. The amount of 4-percent fat-corrected milk increased slightly when cows A75 and

TABLE 2—The results obtained in milk production by replacing clover hay with clover silage when both rations were supplemented with equal amounts of corn

Cow	In milk*	Body weight	Milk	Test	F.C.M.†	Feed intake:			Received	
						Clover hay	Clover silage	Corn	Dig. prot.†	T.D.N.†
No.	*Days*	*Lb.*	*Lb.*	*%*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
A67.....	93	954	32.1	3.8	31.3	24.6	....	8	2.72	19.6
	108	965	33.9	3.7	32.6	24.9	....	8	2.75	19.7
	123	946	34.8	3.7	33.3	....	78.0	8	2.76	19.2
	138	938	34.3	3.5	31.7	....	77.2	8	2.74	19.0
	153	958	33.6	3.5	31.2	25.8	....	8	2.82	20.2
	168	998	31.9	3.6	30.0	25.5	....	8	2.80	20.0
A77.....	48	1077	29.0	3.4	26.7	24.2	....	4	2.32	16.2
	63	1068	28.6	3.5	26.3	24.5	....	4	2.34	16.3
	78	1044	28.6	3.4	26.3	....	79.5	4	2.43	16.2
	93	1035	28.8	3.1	25.1	....	77.8	4	2.38	16.0
	108	1041	27.9	3.2	24.4	25.8	....	4	2.45	17.0
	123	1061	27.1	3.2	23.8	25.4	....	4	2.42	16.8
A76.....	180	1028	17.5	3.7	16.9	24.0	....	2	2.12	14.5
	195	1031	16.8	3.9	16.6	24.6	....	2	2.17	14.8
	210	1041	18.0	3.7	17.2	....	79.9	2	2.26	14.7
	225	1044	18.2	3.4	16.4	....	79.7	2	2.25	14.7
	240	1052	17.1	3.7	16.5	25.8	....	2	2.27	15.4
	255	1060	16.7	3.8	16.2	22.5	....	2	2.00	13.7
A75.....	50	1041	22.1	3.7	21.1	25.0	....	2	2.21	15.0
	65	1037	21.9	3.9	21.5	25.0	....	2	2.21	15.0
	80	1033	22.6	3.6	21.3	....	80.0	2	2.26	14.7
	95	1023	22.6	3.4	20.5	....	80.0	2	2.26	14.7
	110	1019	21.6	3.7	20.6	26.0	....	2	2.29	15.3
	125	1034	21.5	3.5	19.8	26.0	....	2	2.29	15.3

*All trials were 15 days in length.
†Key to abbreviations:
F.C.M. = 4 percent fat-corrected milk
Dig. prot. = Digestible protein
T.D.N. = Total digestible nutrients

A76 (Table 2) were changed from silage to hay, whereas cows A67 and A76 (Table 2) and A72 (Table 3) showed a slight increase when changed from hay to silage. All of the other changes from hay to silage or from silage to hay resulted in a small decline in fat-corrected milk. The data indicate that there was very little difference between the nutritive value of the hay and silage when measured by milk production or by body weight. In all instances, the amounts of total digestible nutrients consumed were slightly higher during the hay-feeding periods, but this appears to be insignificant because all of the cows received more than the recommended allowance.

The results concerning the relative value of the hay and silage from the standpoint of the unidentified factor(s) supplied by grain

and young pasture grass are shown in Table 4. Cow A71 was fed on clover-hay for one 15-day period. During the next 15-day period some of the hay was replaced by 2.4 pounds of dried molasses daily to determine the amount of the grain factor in the molasses mixture. Milk production remained unchanged, but when silage replaced the hay and the dried molasses the amount of fat-corrected milk dropped 2 pounds per day. Cow A73 declined from 16.6 pounds of fat-corrected milk daily on hay alone to 15.4 on silage alone. Cow 78 showed a slight decline in milk production during the 15-day period when the silage intake was increased from 81.1 to 88 pounds per day, but the amount of fat-corrected milk returned to the level of the hay period. When 55 pounds of silage replaced 16.4 pounds of clover hay and 1.4 pounds of dried molasses in the ration of cow 461, fat-corrected milk declined 1.9 pounds per day. Cow A66 was changed from 99.4 pounds

TABLE 3—The results obtained in milk production by replacing clover silage with clover hay when both rations were supplemented with equal amounts of corn

Cow	In milk*	Body weight	Milk	Test	F.C.M.	Feed intake:			Received	
						Clover hay	Clover silage	Corn	Dig. prot.	T.D.N.
No.	*Days*	*Lb.*	*Lb.*	*%*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
419.....	51	1212	43.8	3.3	39.5	....	83.2	11	3.16	22.4
	66	1200	42.6	3.2	37.5	....	79.8	11	3.07	21.8
	81	1181	39.5	3.2	34.6	24.8	....	11	3.01	22.0
	96	1195	40.2	3.2	35.2	24.9	....	11	3.02	22.0
	111	1191	37.3	3.3	33.3	....	75.4	11	2.96	21.1
	126	1198	37.0	3.0	31.1	....	74.8	11	2.94	21.0
A72.....	208	977	16.9	3.7	16.1	....	68.6	2	1.96	12.9
	223	962	17.4	3.6	16.4	....	62.0	2	1.79	11.8
	238	963	17.0	3.6	16.0	21.8	....	2	1.95	13.3
	253	997	16.4	3.8	16.0	24.4	....	2	2.16	14.7
	268	1012	16.7	4.0	16.2	....	74.4	2	2.11	13.8
	283	999	16.7	3.6	15.7	....	70.9	2	2.02	13.2
A33.....	255	1215	20.1	3.6	19.0	....	83.3	4	2.53	16.9
	270	1231	18.4	3.6	17.4	....	80.0	4	2.44	16.3
	285	1237	16.3	3.7	15.5	25.0	....	4	2.39	16.6
	300	1251	14.4	3.6	13.8	24.9	....	4	2.38	16.5
	315	1291	12.7	3.9	12.5	....	76.0	4	2.34	15.7
	330	1328	11.1	4.0	11.0	....	76.0	4	2.34	15.7
A62.....	177	1203	19.0	3.1	16.5	....	83.3	2	2.35	15.3
	192	1214	16.5	2.8	13.7	....	80.0	2	2.26	14.7
	207	1216	14.4	2.8	11.8	24.9	....	2	2.20	14.9
	222	1221	14.4	3.0	12.1	25.0	....	2	2.20	15.0
	237	1249	13.7	2.8	11.8	....	76.0	2	2.16	14.1
	252	1256	13.4	2.8	10.8	....	76.0	2	2.16	14.1

*All trials were 15 days in length.

TABLE 4—The results obtained in milk production by replacing clover hay and various supplements with clover silage

Cow	Experimental period	In milk	Body weight	Milk	Test	F.C.M.	Feed intake:		
							Clover hay	Dried molasses	Clover silage
No.	*Days*	*Days*	*Lb.*	*Lb.*	*%*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
A71	15	48	1017	28.0	3.5	25.9	29.8	....	....
	15	63	987	28.0	3.6	26.3	27.6	2.4	....
	12	78	943	26.4	3.5	24.4	....	....	94.6
	12	90	955	24.6	3.2	21.6	....	....	91.2
A73	15	182	862	18.2	3.4	16.6	28.0	....	....
	21	197	839	16.7	3.4	15.4	....	....	80.2
A78	12	86	987	19.6	3.4	17.8	27.8	....	....
	15	98	981	18.9	3.5	17.5	....	....	81.1
	12	113	976	19.7	3.3	17.6	....	....	88.0
461	12	245	1177	17.8	3.9	17.5	16.4*	1.4	....
	15	257	1212	15.4	4.1	15.8	....	....	55.0
A66	15	192	1028	19.9	3.0	16.9	....	....	99.4
	15	207	1052	18.4	3.3	16.5	32.0	....	....
	9	222	1062	18.1	3.3	16.2	29.5	2.5	....
	24	231	1088	18.7	3.2	16.5	....	....	97.0
A61	9	30	1060	39.6	3.8	38.2	19.4†	16.0‡	....
	24	39	1050	42.6	3.4	38.8	....	14.0‡	50.0

*Received 15 pounds of young brome hay in addition to the clover hay.
†Brome-alfalfa hay.
‡Grain (Corn + soybean oil meal).

of silage to 32 pounds of hay; the amount of fat-corrected milk declined slightly. Milk production declined further when 2.5 pounds of dried molasses replaced 2.5 pounds of hay, but when 97 pounds of silage replaced the hay and dried molasses, a slight increase in milk production occurred.

DISCUSSION

The silage and hay made from alternate windrows of a clover-grass mixture, which was cut when the clover was in about three-fourths bloom and the grass in the bud stage, showed good agreement in the protein and crude fiber content, on the dry basis. The larger amount of ether extract in the silage as compared with that of the hay was probably due to the production of ether extractable compounds formed during fermentation. The higher carotene content of the silage as compared with that of the hay is in agreement with results previously observed by other workers. The hay contained 19 micrograms

of carotene per gram, on the dry basis, and supplied more than enough carotene to maintain the health of the animals. The coefficients of digestibility of dry matter, crude fiber and nitrogen-free extract of the hay and silage were in good agreement. The higher coefficient of digestibility for the ether extract of silage was probably due to the presence of easily absorbed fermentation products. The digestible protein and total digestible nutrient content of the hay and silage were in close agreement.

The data presented in Tables 2 and 3 indicate that the cows produced slightly more fat-corrected milk while on the silage ration than when on the hay ration. The cows consumed slightly more total digestible nutrients and gained more in body weight during the hay-feeding periods. These differences seem insignificant and indicate that silage and hay made by the alternate windrow method are about equal for milk production when compared on the dry matter basis. These results are in agreement with those of Clark (1913) who used this method to compare clover silage and hay. The results do not agree, however, with the results of Pratt and Holdaway (1943) who reported that clover silage produced more milk per pound of dry matter than clover hay. Horwood and Wells (1936) compared alfalfa hay with alfalfa silage and found that the cows receiving the silage produced 310 pounds more fat-corrected milk than did the cows receiving the hay ration. The results reported in this paper are not in agreement with those of Bechdel (1923) who concluded that milk production was higher when clover silage was fed as part of the roughage in the ration than when hay was fed as the only roughage. The history of the hay was not given which conceivably could account for the difference in milk production. In comparing the nutritive value of hay and silage, one finds it necessary to harvest both at the same time and from the same field since, as a rule, more of the grain factor(s) is present in the earlier cut hays. Shepherd *et al.* (1947) and Turk *et al.* (1951) reported no significant difference in milk production when the hay and silage was made from the same field and both harvested at the same time.

In previous reports, data have been presented which showed that mature hay is deficient in a factor supplied by immature hay and grains (Huffman *et al.* 1952). Usually, the first deficiency of a hay for milk production is this factor. The data presented in Table 4 indicate that the hay and silage were about equal in respect to this factor. The dried molasses contained a small amount of grain, but

apparently there was not enough present to affect milk production. These results are in agreement with the findings of Little *et al.* (1953) who compared a mixture of alfalfa-brome-quack conserved as field-cured hay and as silage and fed without a grain supplement.

SUMMARY

Clover hay and silage were made, using the alternate windrow method. The hay was rained on slightly and was graded U. S. No. 1. The silage was of excellent quality as determined by aroma and appearance. The pH was 3.9.

There was good agreement between the hay and silage in protein and nitrogen-free extract content, on the dry basis. The silage contained less crude fiber, but more ether extract and carotene. The coefficients of digestibility of the dry matter, crude fiber and nitrogen-free extract of the hay and silage were in good agreement. The coefficients for protein were lower in the silage and higher for ether extract than for the hay. The digestible protein and the total digestible nutrient content of the hay and silage showed good agreement.

Two lots of four cows each were used in 30-day double-reversal trials to determine the nutritive value of the hay and silage when each ration was supplemented with equal amounts of corn. The results calculated, either by 15-day or 30-day periods, showed no significant difference in the amount of fat-corrected milk produced, in body weight or in the amount of total digestible nutrients consumed.

The clover hay and silage also seemed equal for milk production when grain was not fed in the ration, which indicates that the hay and silage were of equal value as sources of the unidentified lactation factor(s).

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THE NORMAL ANNUAL PATTERN OF MEAN DAILY TEMPERATURES AT EAST LANSING, MICHIGAN[1]

By GEORGE A. CRABB, JR.[2]

THIS REPORT describes the development of a normal annual pattern of mean daily temperatures at East Lansing, Michigan. It is intended as one of a series of papers describing normal patterns of observed hydrologic and meteorologic phenomena at the Michigan Hydrologic Research Station.[3] Wide day-to-day fluctuations noted in the hydrologic records of this station caused such difficulties in comparative analysis of the data that it was necessary to develop a more suitable method of preparing normal annual patterns[4] than those methods in current use. A method of developing such comparison criteria was developed, and applied with considerable success to solar radiation data (Crabb, 1950a and 1950b). The method was later successfully used to prepare a normal annual pattern of daily evaporation from a free-water surface (Crabb, 1952). It has now been utilized in the development of a normal annual pattern of mean daily temperatures.[5] The interdependence of these phenomena has been evaluated through statistical calculation of the correlation coefficient and has been shown to be highly significant in respect to correlation.

The mean daily temperature is found by averaging the maximum and minimum temperatures for any one day, and the resulting figure has generally been adopted as an index because it is much more stable than either the maximum or minimum values of temperature and closely approximates the actual average daily temperature. Baten and Eichmeir (1951) found that there is almost perfect correlation between mean daily temperatures and the "average" temperatures for each of the days. However, even the relatively stable values of the mean

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[3]The Michigan Hydrologic Research Station is a cooperative Research project of the Soil and Water Conservation Research Branch, Agricultural Research Service, U. S. Department of Agriculture, and the Michigan Agricultural Experiment Station.

[4]Not to be confused with the "normal curve" as generally used in statistics.

[5]The author wishes to express his appreciation to Mrs. Nina C. Cottom, Michigan Hydrologic Research Station, for her assistance in the analysis and computation of the data.

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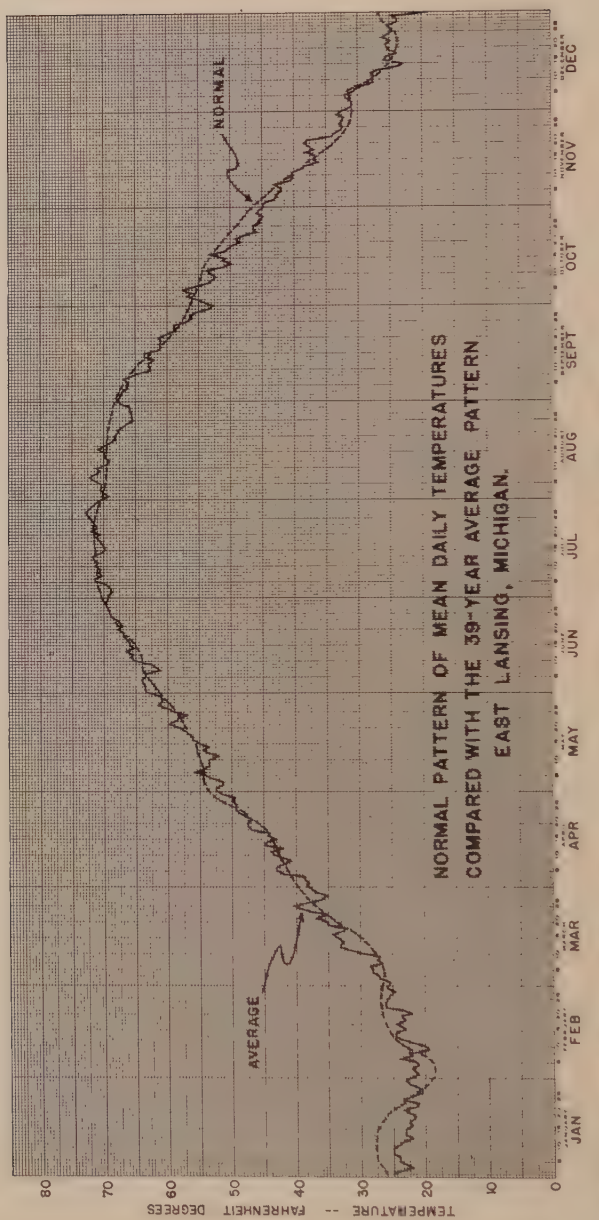

Fig. 1. The normal annual pattern of mean daily temperatures at East Lansing, Michigan.

This pattern, developed from 1947-51 temperature records of the Michigan Hydrologic Research Station, provides a smooth pattern of short-term data which compares favorably with that developed from long-term records.

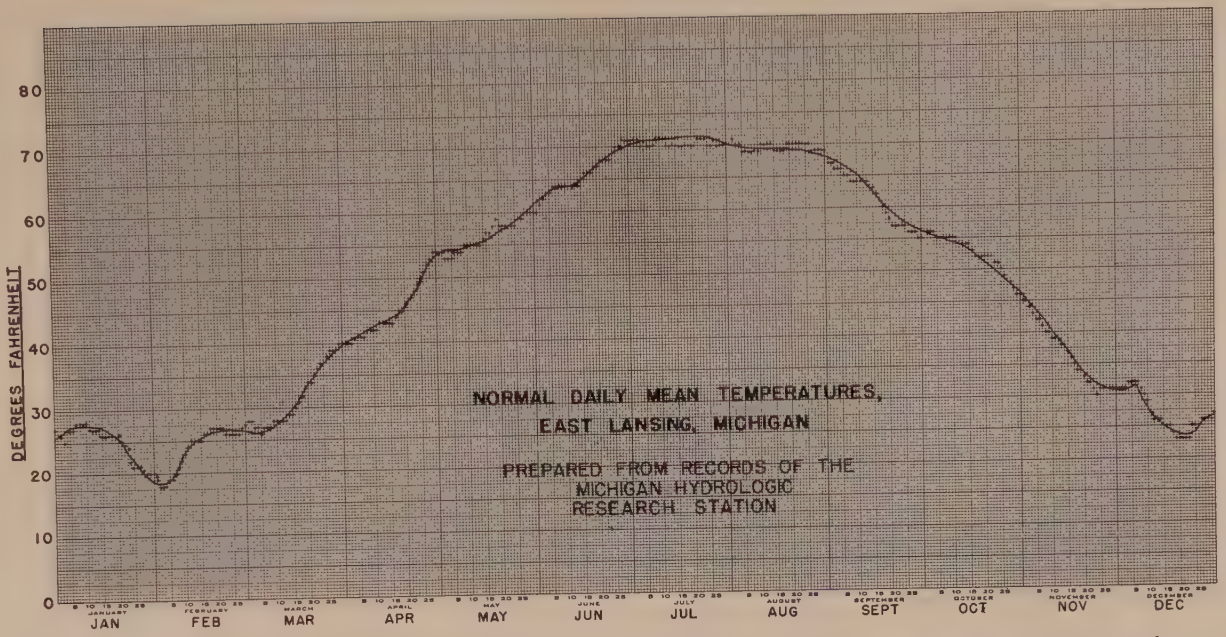

Fig. 2. Comparison between the normal pattern of mean daily temperatures and the average pattern of mean daily temperatures. Note the close overall comparison between the two curves, and the greater regularity of the normal curve (dashed line). The average pattern was derived from arithmetic averages of daily values from a 39-year record, while the normal curve was developed from a 5-year record.

temperature vary to an extent that the desirable smooth curve representative of a normal annual pattern is difficult to achieve—especially when one uses data from stations with relatively short records of observations.[6] The average daily temperature pattern from a 39-year record at East Lansing has proved to present so much variation between daily values as to be of little value as a means of daily comparison (Fig. 2). The method of development of a normal annual pattern of daily values discussed herewith provides a suitable comparison pattern for analyzing long or short-term temperature records, and evaluating their relation to other factors.

DEVELOPMENT

As was true for insolation and evaporation values—it was found that the annual pattern of actual mean daily temperatures and the pattern of average mean daily temperatures showed too much fluctuation to be of value for comparison purposes. However, application of a 15-day moving average produced a moderately smooth and accurate pattern of mean daily values. When such a pattern was prepared from data for five years, and the resulting moving average values were arithmetically calculated for each day of the year for each of the five years, a very smooth spread of data was obtained. When these values were plotted, it was a simple matter to fit a smooth curve to the data, producing an annual pattern of normal values of the daily mean temperature. The pattern was closely comparable to those values actually experienced, and reflected with fidelity seasonal changes, while avoiding the abrupt breaks introduced in such a pattern by sharp daily fluctuations. (Fig. 1.) This pattern, which it must be remembered was prepared from only five years of records, compares very favorably with the pattern resulting from plotting average mean daily temperatures from a 39-year record at the same location. It will be noted that the only significant difference between the two patterns is the fact that the pattern resulting from an average of 39 years of daily temperature values shows considerable day-to-day fluctuation, while following essentially the same trend as the pattern resulting from only five years of record. Smoothness of pattern is of considerable value in any comparison study, and the ability to construct, from short-term records, a reasonably accurate normal annual pattern is highly advantageous.

[6] In the field of meteorology it is not generally customary to attempt to develop a normal pattern of daily values from records of less than 20 years; fifty years would be better, and 100 years still more desirable (Landsberg, 1947).

APPLICATION

In one application to analysis of hydrologic data, this pattern was plotted in conjunction with the normal annual pattern of insolation for the same location (Fig. 3). The combination clearly illustrates the effect of the sun's heat upon the atmospheric temperature, and shows the intimate relationship between the two phenomena. The time-lag apparent between peak values of insolation and temperature represents the average of both maximum and minimum daily temperatures and, as such, reflects the cooling effect of radiation of heat away from the earth during the night hours. This is in agreement with previous studies of the U. S. Weather Bureau (Hand, 1937). Although the greatest amount of sunshine is possible on the longest day of the year, the highest temperatures—both maximum and minimum—do not usually occur until later in the season. The close relationship between insolation and temperature is evident between the two curves, even to the point of reflection of the characteristic peaks and troughs of the solar curve in the temperature curve. Variations between the two patterns may be attributed to the fact that the temperature pattern is a composite figure, and is also affected by thermal coefficients of the earth's surface and atmosphere and by advection of warm and cold air. Calculation of the correlation coefficient to evaluate dependence of these patterns showed their correlation to be highly significant.[7]

Other analyses showed that the temperature pattern is also reflected in the normal annual pattern of daily evaporation losses developed in previous studies (Crabb, 1952). Correlation between the evaporation and temperature patterns was also found to be highly significant (Fig. 3).[8] It will be noted that the general, overall normal pattern of mean temperatures is quite similar to that of evaporation—especially during the spring and fall, a time of regular progression and regression of daily values. The temperature pattern, in general, shows a time-lag of approximately one month behind the evaporation pattern, whereas the time-lag between insolation and temperature is approximately 3 weeks. A highly significant correlation between evaporation and insolation was also observed,[9] illustrating the close inter-relationship of all these three factors.

[7] 0.851 for 365 observations.
[8] 0.359 for 365 observations.
[9] 0.945 for 365 observations.

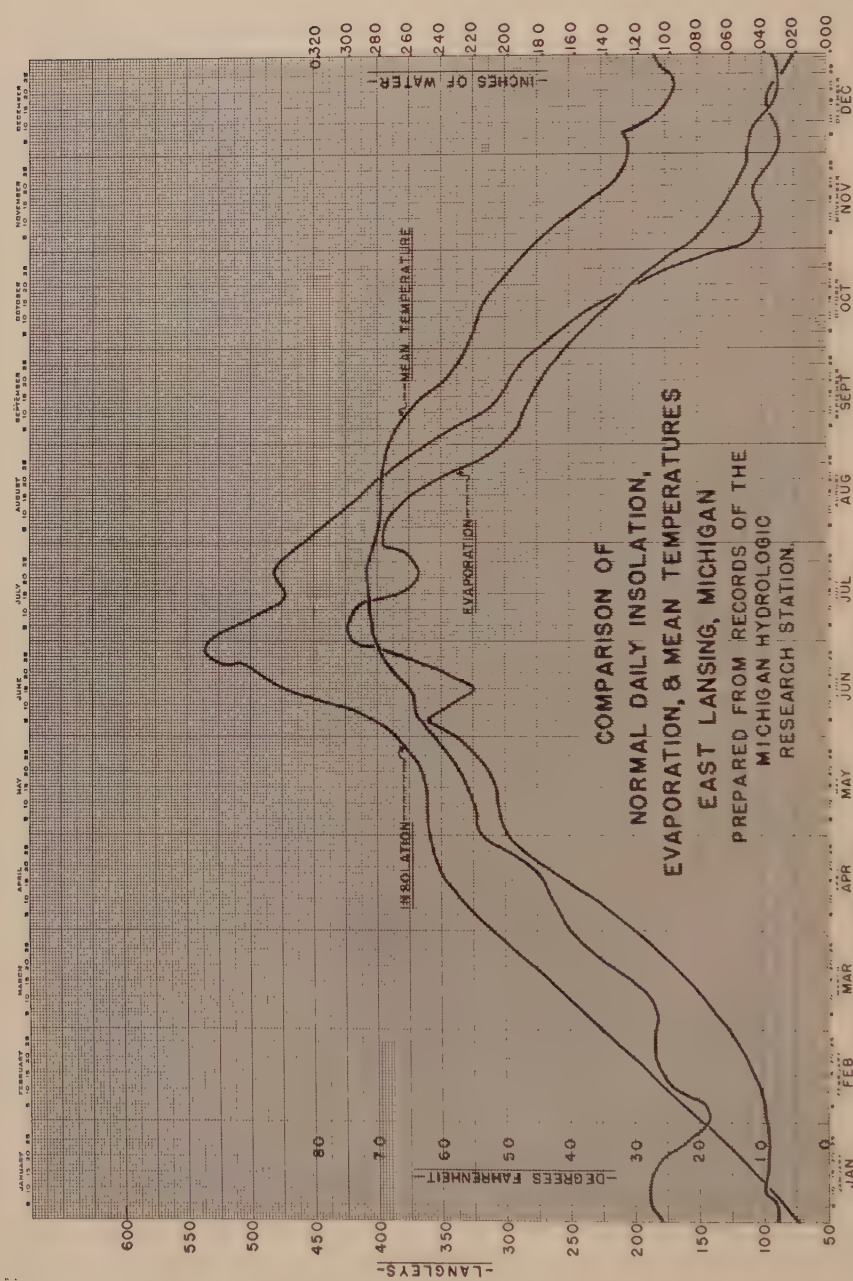

Fig. 3. Comparison of normal annual patterns of daily values of insolation, evaporation, and mean temperature at East Lansing, Michigan. The closeness with which these patterns follow each other are indicative of the intimate relationship between the three phenomena.

TABLE 1 — Normal daily mean temperatures, East Lansing, Michigan. Compiled from an arithmetic average of the daily values of a 15-day moving average, 1947-51

Day	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	26	19	28	40	54	60	71	70	67	56	45	31
2	26	18	28	40	54	61	71	71	67	56	45	31
3	25	18	27	40	53	62	71	70	66	56	44	31
4	27	18	27	41	53	63	70	70	66	56	43	32
5	26	19	26	41	53	63	71	69	66	55	42	32
6	27	19	27	41	54	64	70	69	65	55	42	32
7	28	20	27	41	54	64	70	69	65	55	41	32
8	28	21	27	42	54	64	70	69	64	55	40	31
9	28	22	28	42	55	64	71	69	64	55	40	30
10	28	23	28	42	55	64	71	69	64	55	39	29
11	27	24	28	42	55	64	71	70	64	55	39	27
12	27	25	28	43	55	64	70	70	64	54	39	26
13	27	25	28	43	55	64	70	70	64	54	38	26
14	27	25	29	43	55	64	70	70	63	54	38	26
15	26	25	29	43	56	65	70	69	63	54	37	25
16	26	26	30	43	57	66	70	69	62	53	36	25
17	26	26	31	44	57	66	70	69	61	52	35	25
18	26	27	32	45	58	66	70	69	60	52	34	24
19	26	27	33	45	59	67	70	70	59	52	34	23
20	26	27	34	46	58	67	70	70	58	52	33	23
21	25	27	34	47	58	68	70	70	57	52	32	23
22	24	27	35	47	58	68	71	70	57	52	32	23
23	24	26	36	48	58	68	71	70	57	51	31	23
24	22	26	36	49	58	68	71	70	57	51	30	25
25	21	26	37	50	58	69	70	70	57	50	31	25
26	21	26	37	51	59	70	70	69	56	49	31	25
27	21	26	38	52	59	70	71	69	56	48	31	26
28	20	27	39	53	60	71	70	69	56	48	31	26
29	20	..	39	54	60	71	70	69	55	49	31	26
30	20	..	39	54	60	71	70	69	55	46	31	26
31	20	..	40	..	60	..	70	68	..	46	..	27

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MICHIGAN APPLE STORAGE FACILITIES

By B. C. FRENCH,[1] J. H. LEVIN,[2] and H. P. GASTON[3]

BETWEEN 30 and 40 percent of the apples produced in Michigan are stored for sale or use after the harvesting season. During the past 10 years the stored portion of the crop has represented an average annual farm value of over $3,500,000. Investments in storage facilities required to handle this fruit amount to approximately $5,000,000 in terms of 1952 prices. These figures indicate that storage is of considerable importance to farmers and that the way in which storage operations are conducted may have a substantial influence on the incomes of both producers and handlers of Michigan apples.

This report is concerned with the location, capacities, and utilization of apple storage facilities in Michigan. The data indicate the storage potential in the various producing regions and may be suggestive of where new facilities may or may not be needed. Apple buyers may also find this information useful in determining where winter apple supplies may be found. And the material concerning the size or capacities of storage plants may be of value to agencies interested in apple marketing programs, for it shows the number of storage plants that must be contacted in order to control or influence any proportion of the apple crop stored in Michigan.

LOCATION OF STORAGE FACILITIES IN RELATION TO PRODUCTION

Apple storage facilities in Michigan—both farm and non-farm—are presently capable of holding over 5 million bushels of apples. This is approximately two-thirds of the average production for the 10 years 1944-53. However, as indicated in Fig. 1, the proportion of the crop that can be stored varies considerably among the several apple-

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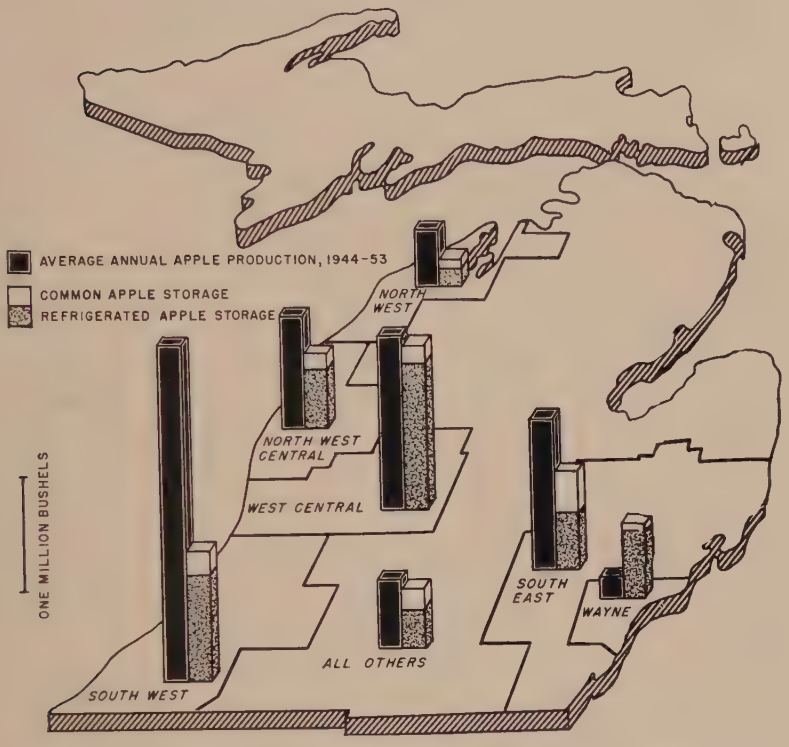

Fig. 1. Location of storage capacity in relation to apple production in the major Michigan apple-producing regions.

producing districts.[4] For example, the leading producing area—the Southwest—has local storage facilities for only 39 percent of an average crop, while the West Central Area can store up to 97 percent of an average crop.

These figures do not necessarily indicate that more storage facilities should be constructed in the different areas. A full evaluation requires comparison of present marketing practices with alternatives involving various amounts of storage. But the bars in Fig. 1 do indicate something about the storage potential in the several districts and are also suggestive of the locational sources of apples during the winter months.

A more detailed summary of storage facilities by counties is given in Table 1. This table shows the number of storage plants in each county, the total capacity of both common and refrigerated storage,

[4]Data apply only to the Lower Peninsula. Information on storages and their capacities was obtained through a survey of plants conducted by J. H. Levin and H. P. Gaston in conjunction with a study of costs of construction and operation of apple storages.

TABLE 1—Michigan apple storage facilities, location and capacity, 1953

	Number of known storage plants*	Apple storage capacity			Average 1944-53 apple production‡	Percent of average production storable locally
		Common†	Refrigerated	Total		
		1,000 Bushels				*Percent*
SOUTHWEST						
Allegan	15	39	131	170	474	36
Berrien-Cass	18	53	558	611	1,499	41
Kalamazoo	13	72	50	122	104	117
Van Buren	10	37	160	197	725	27
Total	56	201	899	1,100	2,802	39
WEST CENTRAL						
Ionia	7	...	148	148	211	70
Kent	70	182	787	969	885	110
Montcalm	7	4	61	65	66	99
Ottawa	12	10	195	205	275	75
Total	96	196	1,191	1,387	1,437	97
NORTHWEST CENTRAL						
Mason	...	...	...	...	162	...
Muskegon	8	30	138	168	189	89
Newaygo	12	37	209	246	158	156
Oceana	14	51	174	225	431	52
Total	34	118	521	639	940	68
NORTHWEST						
Antrim-Gd. Traverse..	4	7	4	11	115	10
Benzie-Manistee-Leelanau	11	67	140	207	358	58
Total	15	74	144	218	473	46
SOUTHEAST						
Genesee	14	47	20	67	74	91
Lapeer	9	40	71	111	83	134
Livingston	7	20	20	40	56	71
Macomb	24	19	179	198	330	60
Monroe	4	23	...	23	78	30
Oakland	54	164	119	283	418	68
St. Clair	6	15	5	20	22	91
Washtenaw	7	17	39	56	136	41
Total	125	345	453	798	1,197	67

TABLE 1—Continued

	Number of known storage plants*	Apple storage capacity			Average 1944-53 apple production‡	Percent of average production storable locally
		Common†	Refrigerated	Total		
		1,000 Bushels				*Percent*
WAYNE COUNTY	12	13	705	718	106	677
ALL OTHERS						
Barry-Eaton	10	26	15	41	44	93
Branch-Hillsdale-St. Joseph	8	23	21	44	105	42
Calhoun	14	30	42	72	100	72
Charlevoix-Clare	4	8	39	47	26	180
Clinton-Shiawassee	7	11	38	49	45	109
Ingham	4	24	36	60	57	105
Jackson	8	27	27	54	81	67
Lenawee	7	39	22	61	63	97
Sanilac	7	15	19	34	25	136
Tuscola	7	24	8	32	37	87
Total	76	227	267	494	583	85
Grand Total (excluding Wayne).	402	1,161	3,475	4,636	7,432	62
Grand Total (including Wayne).	414	1,174	4,180	5,354	7,538	71

*Counties with fewer than four storage plants have been combined with others to avoid disclosure of individual operations.
†Unrefrigerated storage.
‡Apple production figures for all counties are available only in census years. The figures in the table were obtained by multiplying the 1949 (census year) production in each county by the ratio of average 1946-52 production in commercial counties to 1949 production in commercial counties.

the average annual production during the period 1944-53, and the percentage of this average production that can be stored locally.[5]

The table reveals that the Southeastern Area has the largest number of storage plants, with the major concentration being in Oakland County. The West Central Area is next followed by the Southwest, Northwest Central, and the Northwest. Kent County in the West Central Area has more apple storage plants than any other single county.

In terms of total local storage capacity—i.e., storage located within producing areas—the West Central area (Kent County in particular)

[5]It is believed that this table includes nearly all of the apple storage plants in existence in Michigan late in 1953, although it is possible that a very few were overlooked.

ranks first, followed by the Southwest, Southeast, Northwest Central, and Northwest areas. It will be noted that a few counties have storage capacity in excess of average production. In some of these instances, a part of the fruit grown in one county may be stored in another and, of course, in years of large crops most of the excess capacity would be utilized.

Seventy-six percent of the local apple storage capacity is on farms, 14 percent in community or cooperative storage, and the remaining 10 percent is made up of non-farm commercial storages. Virtually all community or cooperative storages are located in the Southwest Area. Commercial storages, on the other hand, are scattered among all districts except in the Southeast. In the latter region the only known non-farm commercial storages are in Detroit and these are primarily terminal rather than local storage facilities.

Table 1 indicates that 74 percent of the local apple storage capacity in Michigan is refrigerated, the remaining 26 percent consisting of unrefrigerated, or "common" storage. Nearly all (96 percent) of the common storages are located on farms. The remaining 4 percent consists of community or cooperative storages. There is no known common non-farm commercial storage.

SIZE OF STORAGE PLANTS

The data in Table 1 reveal that Michigan's 4,710,000 bushels of local apple storage capacity (excluding 644,000 bushels of commercial storage in Detroit) is distributed among more than 400 plants. The plants range in capacity from less than 1,000 to over 100,000 bushels. However, most of the plants are small. For example, 54 percent of the plants have capacities of less than 8,000 bushels, but, although these are large in number, they control only about 17 percent of the available storage space. This factor may be of considerable importance to policy-making or administrative agencies interested in apple-marketing programs, for it indicates that a relatively large volume of storage holdings may be concentrated in a relatively small number of plants.

A general picture of the way in which total storage capacity is distributed among Michigan apple storage plants is given in Fig. 2. The curves in the diagram show the cumulative percentage of capacity represented by various numbers of plants, with the plants arrayed

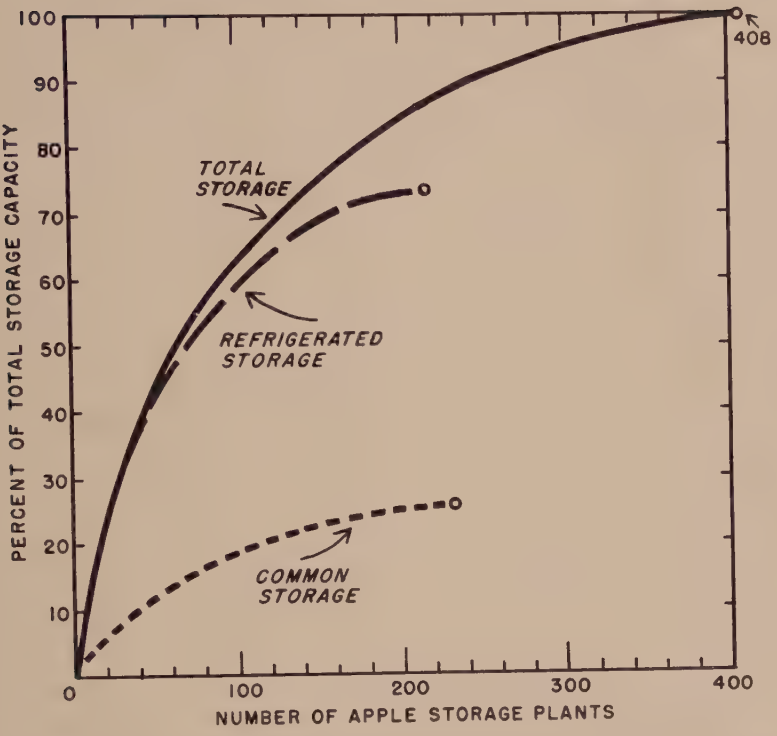

Fig. 2. Cumulative distribution of capacity among Michigan apple storage plants.

from the largest to the smallest. Separate curves are shown for refrigerated, common, and total storage.[6]

The diagram indicates, for example, that the largest 100 plants—about one-fourth of all plants—control approximately 63 percent of the total apple storage capacity and the largest 200 plants control about 85 percent of the available storage space. Or if only refrigerated plants are considered, 100 plants control 59 percent and 200 plants control 73 percent of the total capacity. Figure 2 also shows that common storages are, on the average, considerably smaller than refrigerated storages. The 233 common storage plants account for only 24 percent of the total storage capacity, while the 216 refrigerated plants account for the remaining 76 percent.

[6]It will be noted that the sum of the refrigerated and common storages (216 + 233) is greater than the 408 shown by the total curve. This is because firms with both refrigerated and common storage were counted only once in the total accumulation but twice in computing the refrigerated and common curves. The diagram excludes six Detroit storage plants which are regarded as terminal rather than local storages.

UTILIZATION OF STORAGE FACILITIES

Adequate data concerning the degree to which the storage capacities in the various areas are actually utilized are not available. However, there seems to be a strong trend away from the use of common storage. Estimates of storage holdings computed by the Michigan Apple Commission suggest that only about a third of the available common storage space was actually used during the 1952 and 1953 seasons. On the other hand, over three-fourths of the total refrigerated storage was used, and the utilization was probably much higher for refrigerated farm storage. These utilization estimates are very rough, but they are indicative of approximate magnitudes.

To further illustrate the movement away from common storage, in 1953 over 90,000 bushels of common storage space was converted to refrigeration. In addition, at least 362,000 bushels of new refrigerated storage was constructed but no known new common storage. It may be noted, however, that investments in common storage are relatively small and the extra space does provide a means of "taking up some of the slack" in years of large crops.

STORAGE HOLDINGS AND MOVEMENT OF APPLES IN MICHIGAN AND THE UNITED STATES

By B. C. FRENCH,[1] J. H. LEVIN,[2] and H. P. GASTON[3]

CURRENT ESTIMATES of apple storage holdings provide firms engaged in marketing winter apples with an improved basis for forecasting future prices. For example, larger-than-usual holdings today may foretell of a possible drop in prices during the following weeks as this fruit moves into the markets. If storage estimates are available throughout the season, firms can continually adjust their sales programs so as to minimize market gluts and famines and to promote a more orderly marketing of the apple crop.

These estimates do not, in themselves, provide answers to questions such as when to store, how much to store, or when to sell.[4] However, along with pertinent price data,[5] the estimates can be of considerable aid to management in making decisions with regard to these important questions.

At present there are at least three agencies that compile monthly or semi-monthly estimates of apple-storage holdings. These are the International Apple Association, the Michigan State Apple Commission and the Agricultural Marketing Service, United States Department of Agriculture. Apple Commission estimates, issued twice monthly, apply only to Michigan; while the others, issued once each month, are, on both a state and national basis. These estimates, although current, are nevertheless historical—that is, of necessity, there is a lag of 1 to 3 weeks between the date to which the estimates apply and the date at which they come into the hands of the marketing firms.

For decision-making purposes, it would be more useful, of course, to know the amount of holdings today and, even more important, the movement out of storage over future periods. Perfect predictions of

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[4]For a discussion and analysis of these questions see L. L. Boger (1952). When should apples be sold? Mich. Agr. Expt. Sta., Spec. Bul. 381.
[5]For example, see Boger, *op. cit.*

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future movement are obviously impossible. However, examination of records of storage holdings and movement reveals consistent patterns or relationships which provide a basis for using current data to estimate future storage movement or holdings with a fairly high degree of reliability.

The remaining pages of this article are concerned with the specific nature of these patterns and with the way in which they may be used to predict storage activity. Attention is given first to storage trends, then to the problem of estimating the initial amount of apples entering into storage and, finally, to the problems of predicting holdings or movement and revising these predictions throughout the marketing season. Consideration is given to both Michigan and United States storage activity.

STORAGE TRENDS

Michigan apple producers are storing more of their fruit than ever before. Statistical analysis of Michigan storage data for the years since 1935 indicates that storage holdings, measured on December 1, have been increasing at an average annual rate of 134,400 bushels.[6] Nationally, apple storage holdings have not exhibited any important trend. As a consequence, Michigan apples have become relatively more important in winter apple markets. This is illustrated in Fig. 1 which shows Michigan December 1 holdings as a percentage of national holdings for the period 1935-53.

[6]Storage records compiled by the International Apple Association.

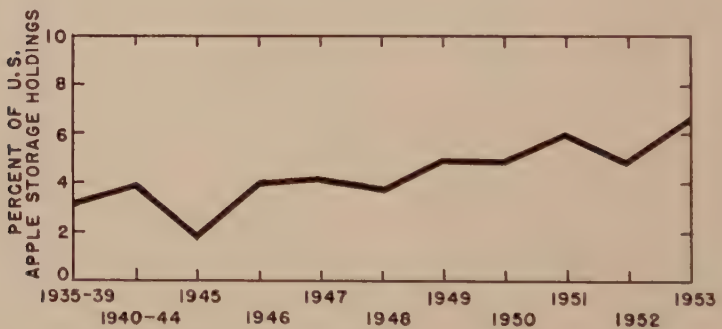

Fig. 1. Relationship of Michigan apple storage holdings to United States holdings.

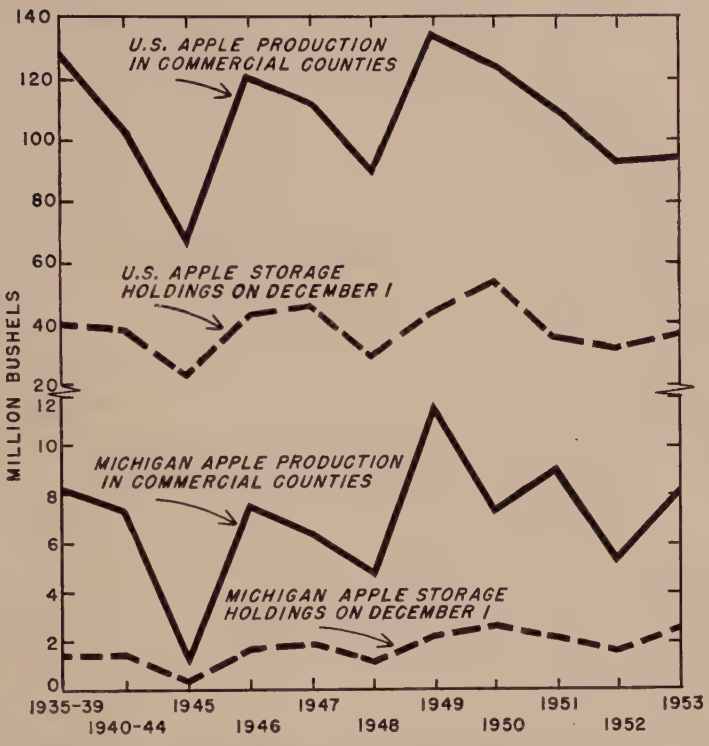

Fig. 2. United States and Michigan apple production and December 1 apple-storage holdings, 1935-53.

This increase in Michigan apple storage represents an important change in the marketing practices of many producers, for total Michigan production, while fluctuating from year to year, has remained fairly uniform over this period. And nationally, production has shown a long-run downward trend.

How long the trend in Michigan apple storage activity will continue is, of course, uncertain. As yet, there is no indication of a leveling off or a downturn. In 1953, space for another 362,000 bushels of apples was added to the growing total of Michigan storage facilities, and there is evidence of further construction in 1954. Available indications suggest that this trend can be expected to continue for at least 2 or 3 more years.

APPLE PRODUCTION AND STORAGE HOLDINGS

Apple production and December 1 storage holdings for the United States and Michigan are shown in Fig. 2 for the period 1935-53.[7] The diagram indicates that both nationally and for Michigan, storage holdings and production tend to move together. Statistical analysis of these data revealed that the average relationships between December 1 holdings and total production are described quite well by the lines in Fig. 3.[8] It will be noted that both Michigan and United States storage holdings are shown in relationship to United States production. United States and Michigan production are highly correlated, and the national figures tend to reflect better the influences of factors other

[7]Michigan Storage holdings tend to reach a peak early in November. Before 1952, reliable estimates of holdings were not readily available prior to December 1. The U. S. Agricultural Marketing Service, and formerly the Production and Marketing Administration, published a series of estimates of cold storage holdings for each month of the year. These records seem to be quite inadequate and, therefore, were not used. Later analysis provides a basis for estimating November 1 stocks from the December data. Data for Fig. 2 were obtained from the International Apple Association and from published reports of the United States Bureau of Agricultural Economics.

[8]The curves in the diagram are based on the following least squares regressions:

$$H_m = 0.277 + 0.0288P + 0.1344t$$
$$H_{us} = 0.434 + 0.3560P$$

where H_m is Michigan apple storage holdings on December 1, H_{us} is United States storage holdings on December 1, P is total United States apple production in commercial areas and t is the year (1952 = 0). All figures except t are in million bushels. For the Michigan regression R = 0.94, and for the United States, R = 0.85.

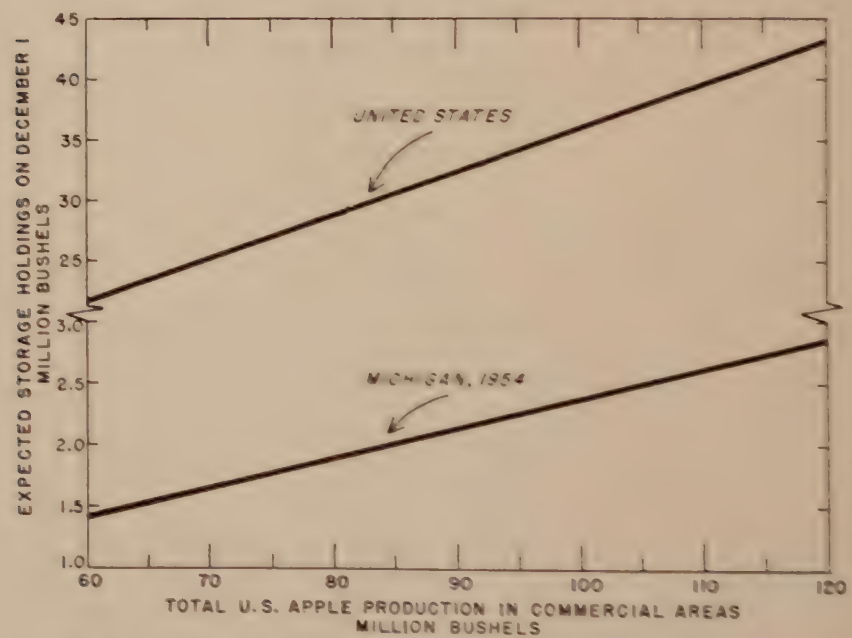

Fig. 3. Average relationship between December 1 apple storage holdings and total United States apple production.

than the Michigan crop size which may affect Michigan storage activity. This would include a complex of past, present, and expected apple prices.[9]

To illustrate the use of Fig. 3, assume that the October or November estimates place the 1954 United States apple crop at 100 million bushels. If historical patterns of storage activity continue, then the expected or "most likely" quantity of storage holdings on December 1 would be 2.4 million bushels in Michigan and 36 million bushels for the United States. On the other hand, if the crop amounted to only 80 million bushels, expected December 1 holdings would be 1.9 and 29 million bushels, respectively. To allow for the storage trend in Michigan, 0.1344 million bushel (134,000) should be added to the Michigan estimates for each year after 1954. Thus 134,000 bushels would be added to the 1955 estimates and 268,800 in 1956.

The lines in Fig. 3 explain about 86 percent of the historical variation in December 1 apple storage holdings in Michigan and about 72 percent of the variation in national holdings. This indicates that production and trend are probably the most important factors which have influenced storage holdings, but they are not the only factors. Storage costs and apple prices, both present and expected, may logically have significant influences. However, the relationships are quite complex and may be reflected to a considerable extent in the levels of production. In this sense, they are partially accounted for in these estimates. More detailed statistical analysis now in progress at Michigan State College may eventually permit estimates of greater precision. But meanwhile, the curves in Fig. 3 provide a fairly reliable and simple basis for determining the most likely quantities of December 1 apple storage holdings.

SEASONAL VARIATION IN STORAGE HOLDINGS AND MOVEMENT

The operator of a storage plant or the owner of stored fruit is, of course, interested in patterns of storage holdings and movement throughout all of the winter and spring months, as well as holdings on December 1. Studies of historical records of storage holdings in other months reveal that there is a consistent relationship between

[9] Attempts to introduce prices directly into the analysis as variables affecting storage holdings failed to yield any significant results, although logically they would have some influence. As prices are also highly correlated with production, their omission may have little effect on the predictive value of the analysis.

holdings in these months and holdings on December 1.[10] This relationship is illustrated for Michigan in Fig. 4. The upper curve shows storage holdings at each point in time throughout the winter months as a percent of the holdings on December 1. Thus, once December 1 holdings are known or estimated from Fig. 3, it is possible to determine the most probable or expected quantity of holdings at any point in the marketing season.

The dots in the diagram represent actual first of the month storage holdings as a percent of December 1 for the period 1935-52.[11] Rates of movement as a percent of December 1 holdings are shown by the lower dashed curve. This curve, calculated directly from the curve showing storage holdings,[12] indicates that rates of storage movement remain fairly uniform and high during late November, December, and early January and then decline fairly rapidly.

Although data were not obtained directly for November, the general pattern of holdings throughout the season plus additional recent data[13] permit the storage curves to be extended back to November 1. If one assumes that holdings have reached their peak by this date, then November 1 holdings might be expected to amount to 117 percent of December 1 holdings. Thus, indirectly, national production can be used to estimate storage holdings at any time during the season.

The curves in Fig. 4 represent the typical or "average" pattern of storage holdings and movement throughout the apple marketing season. However, as the season progresses, new information on actual holdings becomes available and these data may be used to revise and improve the estimates of holdings and movement throughout the remaining parts of the season.

USE OF NEW INFORMATION TO IMPROVE STORAGE PREDICTIONS

Statistical analysis of historical storage records indicates that storage holdings on any particular date are highly correlated with the holdings one month previous. This means that as soon as a storage operator receives information on actual storage holdings as of the first

[10]Records of the International Apple Association.

[11]The periods 1935-39 and 1940-44 are each shown as a single observation.

[12]The rates of movement shown by this curve are the same as the slope of the holdings curve at any point in the season. The area under the movement curve, which may be approximated by summing the average rates of movement for each month, totals 100 percent from December 1 on and 117 percent from November 1 on, as would be expected from the holdings curve.

[13]In 1952, the Michigan State Apple Commission began making semimonthly estimates of storage holdings based on mail questionnaires obtained from a sample of storage plants. These estimates (1952 and 1953) were the source of the November 1 and 15 observations.

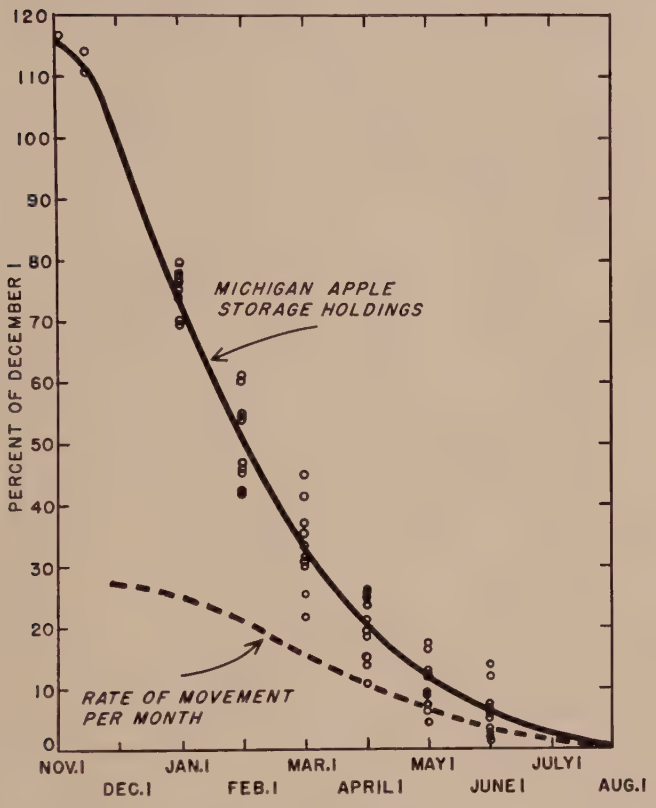

Fig. 4. Typical patterns of seasonal storage holdings and movement of Michigan apples.

of this month[14] he can prepare a revised estimate of expected holdings for the first of the following month. The revised estimate will be somewhat more reliable than the typical curve shown in Fig. 4.

The average relationship between Michigan storage holdings on the first of any month and the holdings on the first of the following month for the period 1935-52 is shown in Fig. 5.[15] To illustrate the use of the diagram, assume that this is November and that November 1 storage holdings are known to be 2,500,000 bushels. To estimate the holdings on December 1, read up from 2500 on the horizontal axis to

[14]From the International Apple Association or the Michigan State Apple Commission.

[15]Based on the following regression equation:

$$X_1 = -19.68 + 0.8216X_2 - 0.0534X_2X_3$$

where X_1 is storage holdings at time i, X_2 is storage holdings at time i minus one month, and X_3 is the month or fraction of a month (time i where December 1 = 0, January 1 = 1, etc.). As an indication of the closeness of the description, R = 0.995. Storage records of the International Apple Association.

the line labeled November 1 (or a particular month). Reading across to the left then indicates that December 1 storage holdings can be expected to be about 2,040,000 bushels.

If December 1 holdings turn out to be exactly 2,040,000, then January 1 holdings may be estimated by reading up from 2,040 to the line labeled December 1. Again reading to the left indicates that January 1 holdings can be expected to amount to about 1,530,000 bushels.

Of course, all predictions do not always come out exactly right. If there were no consistent relationship to the previous month's storage holdings, the typical or average curve in Fig. 4 would have to suffice for predictive purposes. The value of Fig. 5 is that if actual holdings on a particular date differ from expected holdings, the new (actual) figures can be used to provide an adjusted estimate of future holdings. For example, in the illustration used above, if December 1 holdings had in reality been 1,950,000 instead of the expected 2,040,000

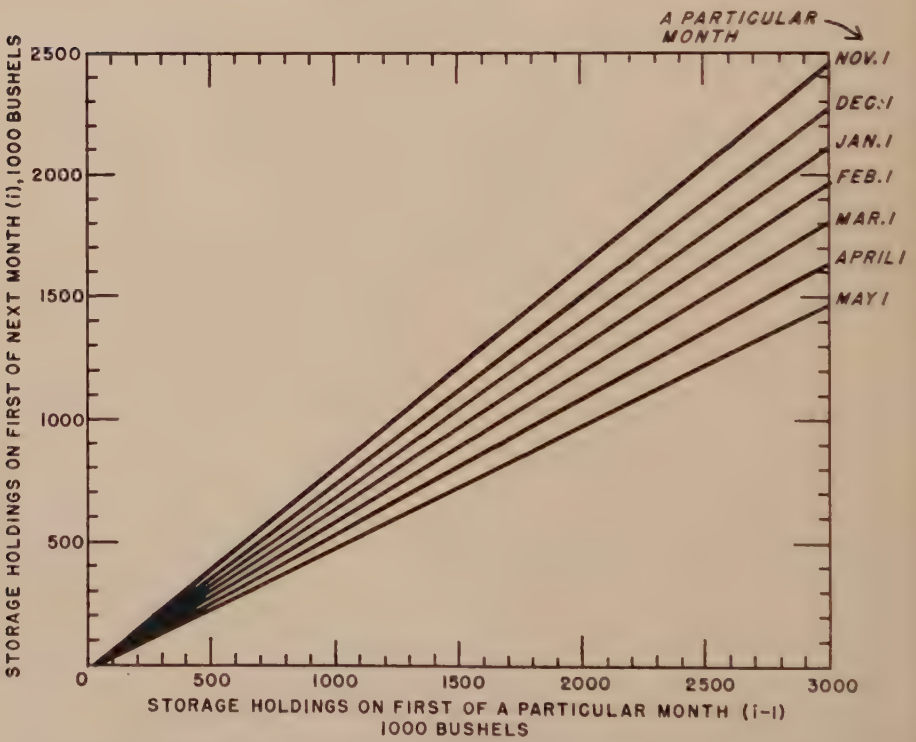

Fig. 5. Relationship between a particular month's storage and the next month's storage holdings in Michigan.

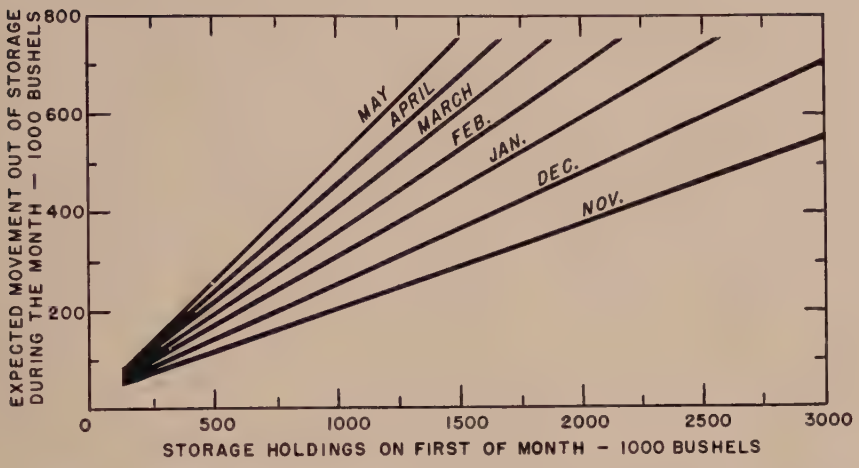

Fig. 6. Relationship between the first of month apple storage holdings in Michigan and the storage movement during the month.

bushels the former figure would have been used to estimate January 1 holdings. The revised estimate for January then would have been 1,475,000 rather than 1,530,000.

Note that it is also possible to interpolate in the use of Fig. 5. To illustrate, assume that November 15 apple storage holdings are known to be 2,600,000 bushels and an estimate of December 15 holdings is desired. Read up from 2,600 to a point half way between the lines labeled November 1 and December 1. Reading to the left indicates that the expected December 15 holdings are about 2,050,000 bushels.

The relationships shown in Fig. 5 "explain" 98 percent of the variation in month-to-month apple storage holdings for the period 1935-52. These relationships are, of course, historical and conceivably might change in the future. But as long as these patterns continue to prevail, the lines in the diagram provide a fairly reliable basis for predicting or adjusting predictions of storage holdings.

The relationships in Fig. 5 can also be expressed in terms of storage movement, rather than holdings. This is done in Fig. 6. The diagram is read in exactly the same manner as is Fig. 5. For example, if November 1 storage holdings are known to be 2,000,000 bushels, expected November movement may be determined by reading up from 2,000 on the horizontal axis to the line labeled November. Reading to the left would indicate an expected November movement of about 375,000 bushels.

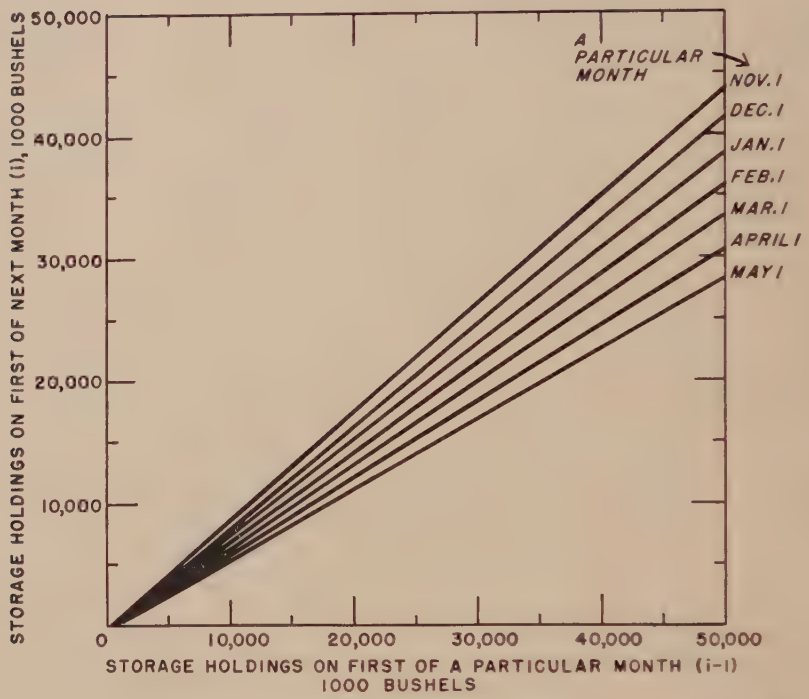

Fig. 7. Relationship between a particular month's storage and the next month's storage holdings in the United States.

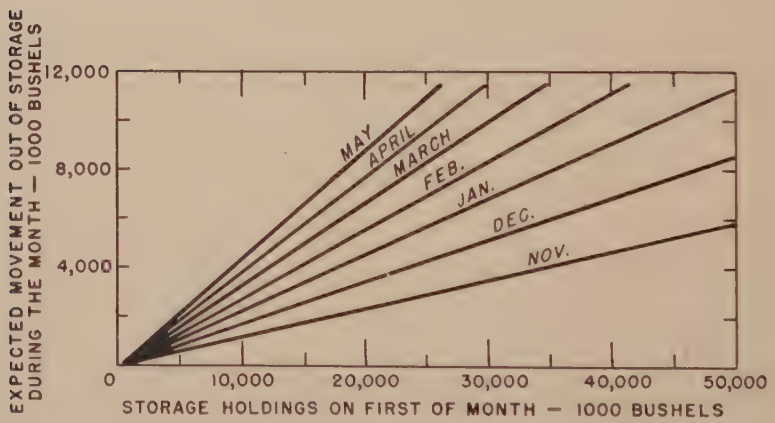

Fig. 8. Relationship between first of month apple storage holdings in the United States and storage movement during the month.

The relationships in Figs. 5 and 6 are repeated on a national basis in Figs. 7 and 8. These diagrams are used in the same manner as Figs. 5 and 6 and provide a basis for estimating expected United States apple storage holdings and movement.[16]

It should be emphasized, finally, that the diagrams presented above are not intended as replacements or substitutes for the material now collected by the International Apple Association and the Michigan State Apple Commission. Rather, they are intended to supplement this information by providing a statistical basis for using these records to predict storage holdings and movement over future periods.

[16]Figure 7 is based on the following regression equation:

$$X_1 = -1.09 + 0.882X_2 - 0.0532X_2X_3$$

where X_1 is storage holdings at time i, X_2 is storage holdings at time i minus one month, and X_3 is the month or fraction of a month (December 1 = 0, January 1 = 1, etc.). R = 0.997. Figure 8 is calculated from Fig. 7.

AN EXPERIMENTAL, HYDRAULICALLY MANIPULATED, BLUEBERRY WEEDER[1]

By W. M. CARLETON and DWIGHT KAMPE[2]
DEPARTMENT OF AGRICULTURAL ENGINEERING

BLUEBERRIES are customarily set on 4- by 10-foot spacings which permit the grower to drive between the rows with his tractor and a tillage implement. The 4-foot spacing in the row, however, prevents working in the other direction. Although chemicals, fire, grazing, fallowing, and mulching are methods that have been advocated to reduce the cost of weed removal in the row, they have not been very satisfactory.

For the removal of weeds between the plants in the row, blueberry growers rely principally on hand labor. This may cost $20 or more an acre, perhaps twice a year.

One mechanical weeding method used in the row area consists of a special blade, called a grape hoe, so set that as it is pulled down the row it scrapes the soil out of the row during one cultivation and pushes it back during the next. The blade is manipulated by a set of handles to move it out of the row, around the bush, and back into the row again after the bush has been passed. This method does, however, leave a large area for hand hoeing and, after prolonged use, results in a definite hilling of the rows.

Experimental work in the Agricultural Engineering Department was directed toward the development of a mechanical weeder which could be maneuvered into and out of the row between bushes by means of hydraulic power. Although designed principally for blueberry cultivation, the system might be applied, the authors felt, equally well to crops such as grapes and raspberries.

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[1]This article is based on information contained in a thesis by the junior author: Kampe, D. F. (1953). A control system for the power manipulation of a blueberry weeder. Thesis for degree of M. S., Mich. State Col., East Lansing. (Unpublished)

[2]Professor of Agricultural Engineering, Michigan State College, and Design Engineer, Ford Tractor Division, Ford Motor Company, respectively. Mr. Kampe was formerly a graduate assistant in the Agricultural Engineering Department.

Acknowledgments: Preliminary work was done on this project by Carl Hall of the Agricultural Engineering Department. Credit is due the Ford Tractor Division for the use of a tractor during the tests. J. H. Levin, U. S. Department of Agriculture, and H. P. Gaston, Department of Horticulture, furnished assistance.

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EXPERIMENTAL WORK

THE TIME FACTOR

The speed of movement in and out of the row is very important in power operation of a cultivator. A tractor moving at a speed of 1 mile per hour along a row of bushes spaced 4 feet apart will move from one bush to the next in 2.7 seconds. Only three-tenths second will elapse while passing a 6-inch diameter group of stems. Even at this slow tractor speed, the weeder will move between the bushes so quickly that it is necessary to provide mechanical operation of a hydraulic valving system designed to move the weeder in and out of the row. The control system is required for moving the weeding head out of the row as far as necessary. At the same time the best possible ground coverage should be obtained. In the work reported, hydraulic power was used since it produces the type and rapidity of motion that was needed. Hydraulic valves also offer a fair ease of control.

HYDRAULIC CONTROL SYSTEM

Since the weeder operated with the head fully extended into the row most of the time, power to move the head laterally was needed only when it was being retracted to maneuver around a bush. By using a spring to extend the weeding head and to hold it in this position

Fig. 1. First experimental machine, showing general construction.

(Fig. 1), the hydraulic system was relieved of pressure while the head was extended. This pressure relief prevented the generation of excessive heat within the oil caused by working the pump against pressure while doing no external work.

The hydraulic control system selected permitted the use of a single-acting cylinder and a simple two-way circuit.

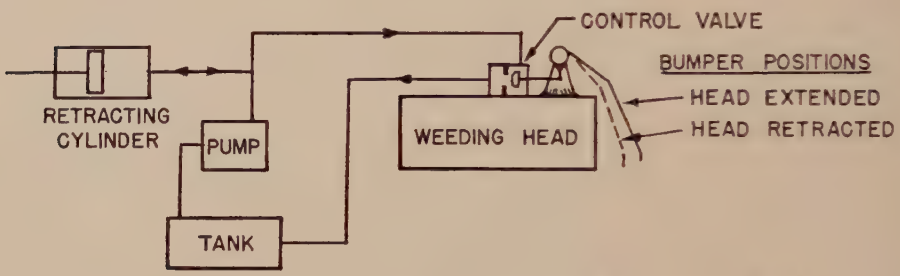

Fig. 2. First hydraulic circuit for controlling the weeding head.

In operation, the weeder with this control system moved down the row, with the end of the weeding head extended just past the center line of the row. With the bumper free, oil flowed from the pump through the control valve, and back to the tank (Fig. 2). The extension spring held the head in place. When the bumper came in contact with the bush, it caused the valve to close, directing oil into the cylinder and retracting the head.

Since the bumper contact with the bush operated the control valve, the force required to operate the valve had to be kept small to prevent damage to the bush. The control valve, especially designed for this circuit, consisted of a two-land spool operating in a bore with the inlet and outlet ports entering between the two lands. With this arrangement, the area exposed to the oil was the same on both lands and the force exerted by the oil, consequently, was the same in both directions. This valve remained balanced at all times and could be moved with a small force regardless of any change in pressure that might occur in the hydraulic circuit.

The performance of the control system in preliminary trials was, in general, satisfactory since the system was able to maneuver the head around each bush without assistance from the operator. The bumper proved to be a satisfactory sensing method, the control circuit functioned as planned, and the two worked well together. However, the inherent instability of the system, although apparently not detrimental

to the operation, was objectionable to observe. The "hunt" while maneuvering around a bush made the machine erratic to a noticeable extent.

A second objection to the machine was related to the method of depth regulation. The depth shoe needed to be closer to the weeding head in order that the rotating weeder would cultivate at a set depth between the plants.

SECOND EXPERIMENTAL MACHINE

The second experimental machine is shown in Figs. 3, 4, 5, and 6. The frame of the new weeder was basically a vertically pinned four-bar linkage that was used to support the weeding head and which would permit it to move laterally in and out of the row. Since the weeding head and this upper frame member would move as a unit, the depth shoe (A in Fig. 3) was positioned in front of the weeding head and was attached to the outer end of the upper frame member.

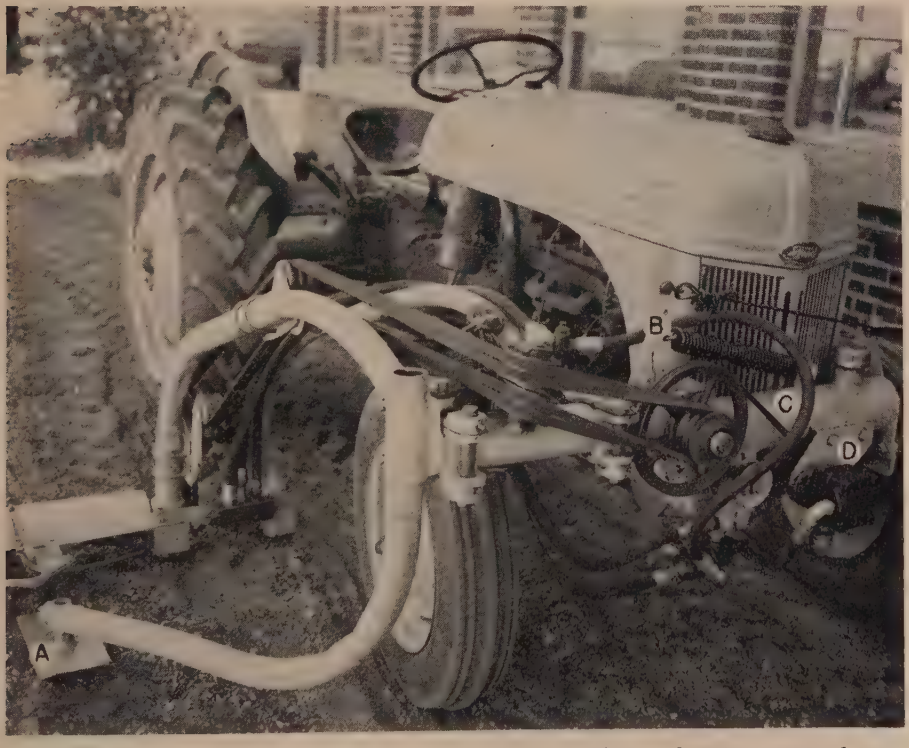

Fig. 3. Front view of second experimental machine, showing general construction and method of attachment to tractor. Letters "A-B-C-D" refer to parts mentioned in the text.

Therefore, the weeding head moved up or down with the shoe, resulting in satisfactory depth regulation. An arm (B in Fig. 3) was attached to the upper frame member with a cable running to the tractor lift to swing the head up for transport.

The central frame section served as a mount for the belt drive to the weeding head (C in Fig. 3). This belt drive originated at the front of the engine, ran over the frame pivot, along the outer curved arm, and down to the weeding head.

The hydraulic pump (D in Fig. 3) was mounted on the central frame section and was driven from the front of the engine with the same drive that was used for the weeding head. This hollow central frame section served as the oil reservoir.

The control valve (E in Fig. 5) was moved from its position on the weeding head to a position between the two curved arms, but it was still operated by a link directly from the bumper.

Fig. 4. Rear view of second experimental machine, showing the relative positions of the weeding head and the depth control shoe.

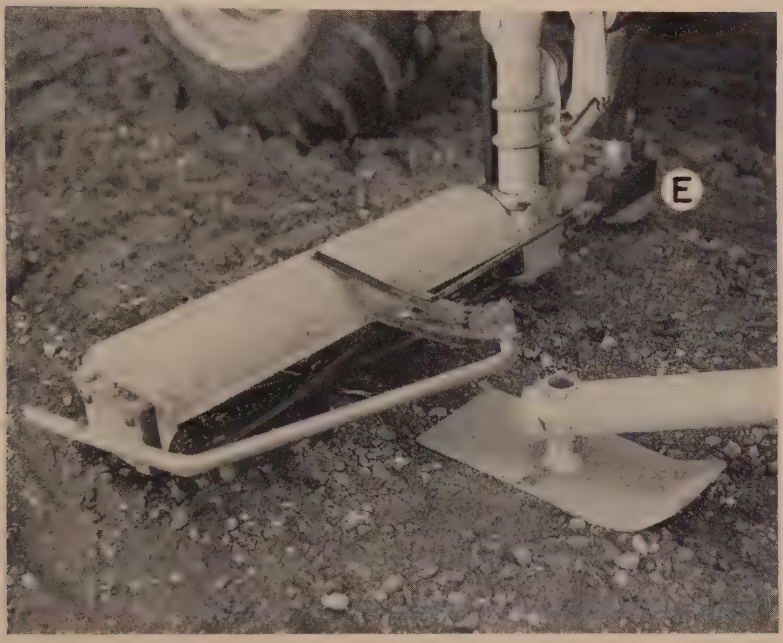

Fig. 5. Close-up view of second experimental machine, showing sensing arm, hydraulic valve location E and depth shoe.

One end of the hydraulic cylinder (F in Fig. 6) was attached to the outer end of the upper frame member, and the other end was attached to the inner one of the two curved head support arms. The extension springs (G in Fig. 6) were attached to the bottom of the upper frame member to make room for the head drive belts.

The new control circuit (Fig. 7) was the same basic type as used on the first machine. In this new circuit, however, the oil entered the cylinder through a check valve so it could not be forced out as soon as the pump line was opened to the tank again. This allowed the head to be stopped and held in place rather than reversing its motion when the bumper moved away from a bush. When the head was to be extended, oil was released through a separate line to the tank from the control valve.

The control valve contained the regular shut-off for the pump-to-tank line and an additional shut-off for the cylinder-return line. Both of these shut-offs were balanced and were arranged so that as the valve was moved from the open position the cylinder-return shut-off occurred first. As the valve spool continued to move, this line remained

shut off and the tank shut-off occurred after the spool had moved farther on in its travel.

The control circuit shown in Fig. 7 gives the control valve three positions. With both sections of the valve open and the bumper free, the head is allowed to extend to its full length. With both sections of the valve shut off, oil is forced into the cylinder and is not able to escape, thus putting the control valve in the retracted position. Between these two positions exists a third position with the pump line open but the cylinder return line closed. The third position is a "hold" position since no oil is forced into the cylinder but neither can any escape.

During preliminary tests of this machine, it was found that considerable instability was evident in that the weeding head tended to "hunt" for a position. An analysis indicated that the trouble was occurring because the first energy supplied to the cylinder was being stored somewhere in the frame owing to deflections in the arms, hydraulic lines, or other places and was being released during the first part of the stroke so as to increase the lateral speed. Corrective meas-

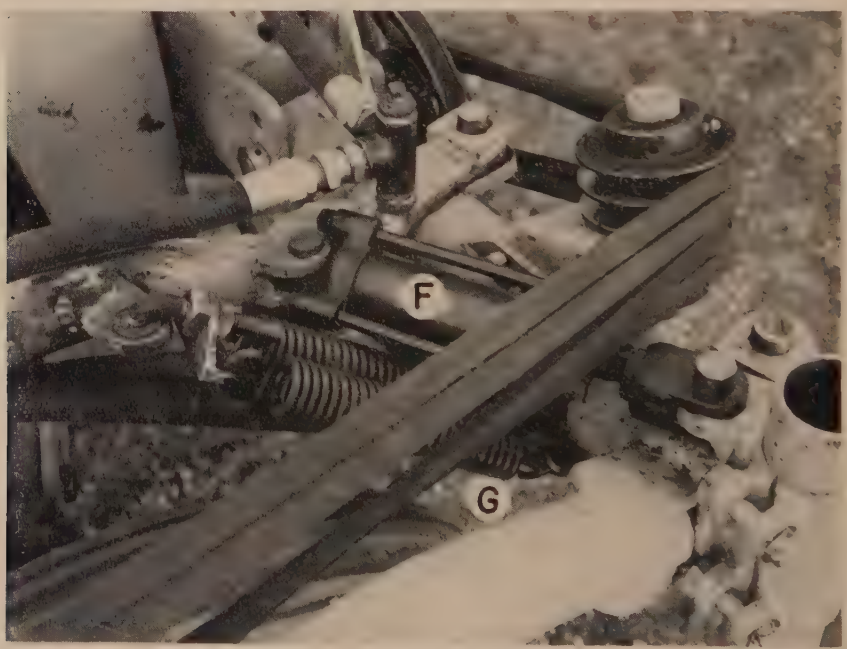

Fig. 6. Close-up view of second experimental machine, showing belt drive, hydraulic cylinder F, and retracting spring arrangement G.

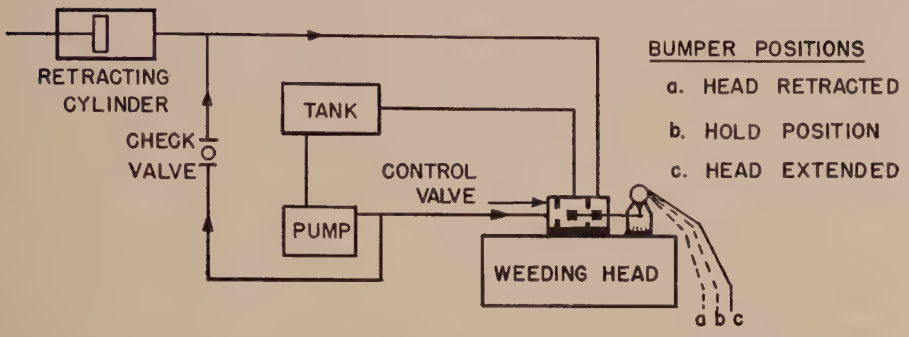

Fig. 7. Revised hydraulic control circuit, on second experimental machine, incorporating provisions for three positions of the tillage head.

ures included replacement of the extension springs with stronger ones, and a modification of the control valve to incorporate tapered metering slots which allowed a gradual buildup of pressure so as to produce a more uniform acceleration of the head.

FIELD TESTS

Several tests were run on blueberries. The depth control system operated satisfactorily. The new control system with the hold position provided much improved control. However, the higher retraction speed, while producing better ground coverage, was satisfactory only within the limited operating range of 0 to 600 R. P. M. engine speed in low gear.

The weeder as a unit was successful up to 600 engine R. P. M. in low gear since there was a definite limit on the speed at which it could be operated. The performance of the control system was more responsive to speed changes than to changes in the control elements, which indicated that the source of the over travel was tied very closely to the weight of the weeding head and the natural frequency of the head and frame as a unit.

The 18-inch total movement of the weeding head was adequate, since the depth shoe served as an indicator for keeping the weeder properly oriented between the rows.

The cutting action of the weeding head was highly successful on weeds and grasses up to about 4 to 6 inches in height. Larger plants, especially grasses, were not removed as effectively as desired.

DESIRABLE FUTURE WORK

If future work is done on a blueberry weeder, it should be performed along the following lines:

1. Incorporate desirable features of the two experimental machines—
   - A. The hydraulic control system with the "hold" position of the second machine.
   - B. The depth control system of the second machine.
   - C. The location of the hydraulic cylinder relative to the weeding head, as found on the first machine. This feature eliminated considerable moving weight with the resultant undesirable inertia effects.

2. Design a control system to provide more positive control of the weeding head by the use of a double acting cylinder.

3. Investigate different types of weeding heads with respect to weeding efficiency.

4. Investigate further the bumper as a control sensing element; the effects of length, surface area, and mounting positions.

5. Investigate the requirements for a control system which will give smooth control at higher speeds.

USE OF CHROMATIC ILLUMINATION AND METHODS OF PRODUCT ROTATION FOR SORTING RED TART CHERRIES

By B. F. PARKER[1] and D. E. WIANT[2]
DEPARTMENT OF AGRICULTURAL ENGINEERING

EXPERIMENTS were conducted during 1953 on techniques for improving the sorting efficiency of workers in cherry processing plants. Two factors were investigated: illumination and rotation of cherries. These were considered to be very important for improving sorting efficiency in cherry processing plants. The purpose of the lighting investigation was to determine the possibility of improving the visibility of defective cherries by selection of the spectral distribution of the illuminant. The aim of rotating the cherries was to bring the entire cherry surface into the worker's view. A review of available literature showed that sorting efficiency can be improved by rotating the product as it moves past the workers on the sorting belt. Efforts were made to develop a device for rotating cherries on sorting belts. Two devices to rotate cherries were developed and tested.

ILLUMINATION

There are three important aspects of illumination: amount, diffuseness or direction, and spectral distribution. The main concern of this project was the spectral distribution; however, the other two factors were not entirely neglected. Spectral distribution is that property of an illuminant which shows the amount of each color produced by the illuminant. It is known that fluorescent lamps are different

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in appearance (color) from the common incandescent filament lamp. Also, various types of fluorescent lamps which appear white actually differ in color. By applying colored filters to these lamps one may obtain considerably different spectral distribution of illumination—even to the extent of producing chromatic illumination. It is the color properties of the illuminant with which the authors were concerned.

TYPES OF DEFECTS AND REFLECTANCE CURVES

In order to analyze the problem of visibility difference between cherries and cherry defects, it was necessary to obtain reflectance curves of cherries and their defects (Fig. 1). These curves show the amount of each color reflected by cherries and cherry defects. (Note the region of the spectrum for each color at the top of Fig. 1). Figure

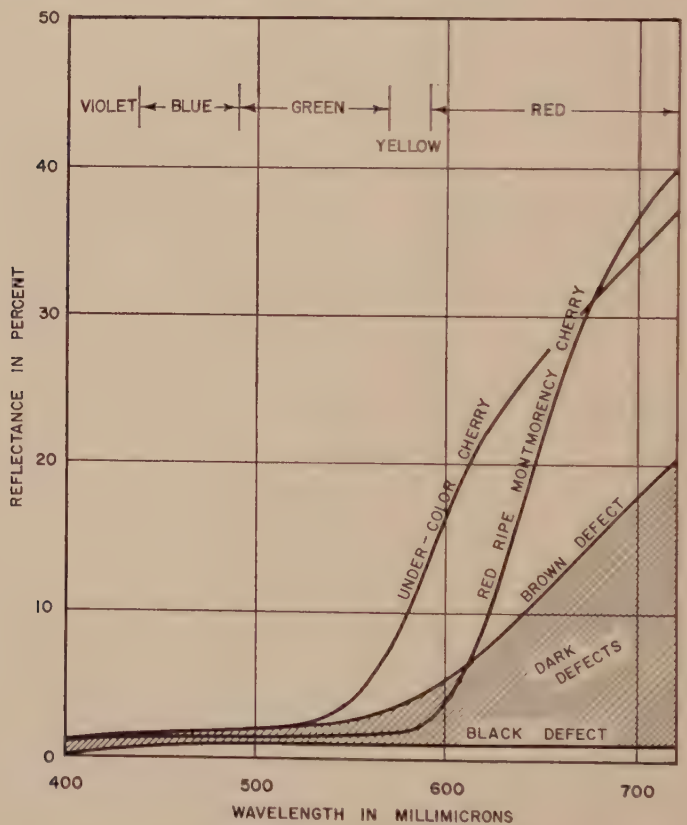

Fig. 1. 45° - 0° spectral reflectance curves for red tart cherries.

1 shows that red-ripe cherries reflect a small amount of yellow light and a large amount of red light. This is the reason for the cherry appearing red. Black defects, which are commonly caused by wind whip, bird pecks, and hail damage when the cherry is nearing maturity, reflect very little light of any color. The brown defects reflect more yellow but less red than do red-ripe cherries, and the under-color defects, mainly immature cherries, reflect much more yellow light than do red cherries. One can see from these curves that the lightness of an object depends on the amount of light reflected by the object; for that reason, the under-colored cherries are lighter than the red-ripe ones and the brown and black defects are darker. In processing plants, the main efforts are directed toward removing a range of defects from brown rot to black. These defects are designated hereafter as dark defects; they usually lower the grade more rapidly than lighter defects. However, in some processing plants, especially when the cherries are being frozen, it is desirable to remove the under-color cherries. These two groups of defects will be considered separately.

THREE COMMERCIALLY AVAILABLE ILLUMINANTS

A number of commercially available illuminants were considered, and three illuminants which represented a wide range of spectral distributions were chosen. These were: the daylight fluorescent, having a large part of its radiation in the green and blue regions of the spectrum; the G. E. deluxe warm white fluorescent, having considerable radiation in the yellow-red region of the spectrum; and the 2910° K tungsten incandescent filament lamp (approximately 150-watt bulb), which has a large amount of its radiation in the red region of the spectrum. A theoretical analysis was made, using these illuminants with various types of gelatine filters in order to produce a spectral distribution which would enhance the visibility of defects on cherries. The results of this analysis are shown in Table 1, where the columns entitled "Contrast Ratio" give an indication of the lightness contrast for each defect. (Hue and saturation differences were of relatively minor importance.) The column entitled "Relative Luminous Flux Reflected from Red Ripe Cherries per Watt" is a relative measure of illuminant efficiency when using the lightness of the cherry as the criterion of measurement. It is desirable to choose a contrast ratio which departs as far as possible from unity; a contrast ratio of 2/1 may be expressed as ½ (these are equal). At the same

time, the largest value of luminous flux reflected from the cherry is desired.

Table 1 shows that the deluxe warm white fluorescent lamp has the highest efficiency, but possesses slightly lower contrast ratios than the 2910° K tungsten lamp. There are several possible illuminant-filter combinations which might be chosen from this table. Filter B-19 offers an advantage in illuminant efficiency, especially for the deluxe warm white fluorescent lamp. On the other hand, the B-20

TABLE 1—Contrast ratios and relative luminous flux reflected from cherries illuminated by fluorescent or incandescent lamp with commercial filters

Illuminant	Filter*	Contrast ratios†			Relative luminous flux reflected from red-ripe cherries per watt
		Under-color defect	Brown defect	Black defect	
G. E. daylight fluorescent	none	1/3.09	1/1.38	2.56/1	211
	B- 7, Dark rose pink	1/3.03	1/1.04	5.11/1	95.6
	B-11, Medium magenta	1/2.64	1.07/1	5.89/1	68.5
	B-18, Medium lavender	1/1.44	1.24/1	4.03/1	45.5
	B-19, Dark lavender	1/2.46	1/1.04	3.93/1	65.0
	B-20, Light purple	1/1.73	1.05/1	3.54/1	23.0
	B-23, Medium purple	1/1.92	1.01/1	3.52/1	35.6
	B-67, Fire red	1/2.20	1.32/1	8.18/1	44.1
G.E. deluxe warm white fluorescent	none	1/2.85	1/1.15	3.63/1	253
	B- 7, Dark rose pink	1/2.63	1.11/1	6.73/1	156
	B-11, Medium magenta	1/2.35	1.23/1	7.90/1	118
	B-18, Medium lavender	1/1.70	1.33/1	6.50/1	50.5
	B-19, Dark lavender	1/2.22	1.19/1	6.43/1	99.6
	B-20, Light purple	1/1.61	1.43/1	7.80/1	35.1
	B-23, Medium purple	1/1.78	1.33/1	6.96/1	52.4
	B-67, Fire red	1 1.95	1.47 1	11.3 1	90.0
2910° K tungsten Approx. 150-watt filament type lamp	none	1/2.52	1/1.04	4.14/1	103
	B- 7, Dark rose pink	1/2.27	1.25/1	8.20/1	67.0
	B-11, Medium magenta	1/2.01	1.33/1	9.74/1	53.5
	B-18, Medium lavender	1/1.47	1.49/1	8.20/1	29.6
	B-19, Dark lavender	1/1.89	1.28/1	7.90/1	47.9
	B-20, Light purple	1/1.38	1.60/1	10.0/1	22.4
	B-23, Medium purple	1/1.53	1.50/1	8.72/1	29.7
	B-67, Fire red	1/1.70	1.68/1	13.8/1	44.5

*Filter numbers are those designated by the manufacturer: Brigham Gelatine Company, Randolph, Vermont.

†Calculations were made at 10 Mu increments.

produces a much greater contrast ratio (the measure of the lightness contrast) when using the tungsten lamp, but the efficiency is rather low. These filters will be discussed from another viewpoint, later.

TEST IN CHERRY PROCESSING PLANTS

Colored illumination tests were conducted in three cherry processing plants. The filters (B-7, B-11, B-23, and B-67) used over the illuminant are listed in Table 1. The G. E. Deluxe Warm White fluorescent or incandescent filament lamps (150 watt) were used in the tests. In the first several days of the tests, it was established that filters B-7 (dark rose-pink) and B-67 (fire red) should be eliminated because of complaints from the workers. Some workers complained that the red and pink illuminants caused eyestrain and headaches. In another limited test, filter B-11 was eliminated because filter B-23 was preferred by the workers. Filter B-23 was then tested for six 5-hour periods. During each 5-hour period six samples (about 400 cherries each) were taken from the belt illuminated by the filtered light and from a comparison belt receiving unfiltered light. Also, samples were taken from the same batch of unsorted cherries as they entered the plant. The tests were conducted with the chromatic illuminant on one belt for 2½ hours and then the filter was switched to the light source for the other belt for 2½ hours. The same number of workers were kept on each belt during a given test. The number of lamp bulbs was doubled in the fixture on which the filter was used since the filter absorbed some of the light.

The results of the tests using chromatic illumination, produced by 150-watt incandescent filament lamps and filter B-23, are shown with the statistical t-values in Table 2.[3] These results compare rather favorably with the theoretically calculated contrast ratios (the measure of lightness contrast). For the minor defects there was a decrease in sorting efficiency of 1.4 percent (not statistically significant) and if one considers the reflectance curve for the under-color cherry as representative of these defects, this contrast ratio is decreased from 1/2.52 to 1/1.53 by using filter B-23 (Table 1). For brown defects the increase in sorting efficiency amounted to 7.8 percent (not statistically significant) and the contrast ratio was increased from 1/1.04 to 1.50/1 for the filter. For the black defects there was an increase in sorting

[3]The complete analysis and test data are presented in a thesis by the senior author: Parker, Blaine F. (1954). Some effects of chromatic illumination, reflectance, and product rotation on sorting efficiency of cherries and tomatoes. Thesis for degree of M.S., Mich. State Col., East Lansing. (Unpublished)

efficiency of 14.6 percent (statistically significant at the 95 percent confidence interval) and the contrast ratio was increased by use of filter B-23 from 4.14/1 to 8.72/1. Apparently, the results for each type of defect compare well with the calculated contrast ratios.

The totals of major defects (i.e., black plus brown defects) are also shown in Table 2. The increase in sorting efficiency for the total was 9.7 percent (statistically significant at the 95-percent confidence interval). The total defects were also obtained by weighing the black and brown defects. This is the measure used by U.S. Department of Agriculture at the plant. By this measure, the sorting efficiency was increased 10.1 percent (statistically significant at the 95-percent confidence interval).

There are several measures which may be used as an indicator of the improvement brought about by use of the chromatic illumination, namely:

TABLE 2—Summary of test at plant C, using 150-watt filament-type incandescent lamps and filter B-23 as indicated

	Minor defects	Major defects		Total major defects	
		Brown	Black	By count	By weight
Percent defects in field cherries before sorting	4.34	6.65	2.48	9.13	8.61
Sorted under regular light					
Percent removed	0.76	0.93	0.78	1.71	1.57
Percent sorting efficiency	17.5	14.0	31.4	18.7	18.2
Sorted under filtered light					
Percent removed	0.70	1.45	1.14	2.59	2.44
Percent sorting efficiency	16.1	21.8	46.0	28.4	28.3
Percent removed filtered light minus percent removed regular light	−0.06	0.52	0.36	0.88	0.87
Percent sorting efficiency filtered light minus percent sorting efficiency regular light	−1.4	7.8	14.6	9.7	10.1
Percent improvement in sorting efficiency using regular light as 100%	−8	56	46	51	55
*Statistical t-values for samples	1.18	1.65	2.21	2.19	2.47

*For statistical significance at the 95-percent confidence interval, t = 2.04.

1. The difference in the amount of cherries removed under each illuminant.

2. The difference in sorting efficiency.

3. The improvement in sorting efficiency, using the regular illuminant as 100 percent.

In reference to the first measure, column 4 of Table 2 shows how many more defective cherries were removed in percentage of the total cherries carried on the belt; for example, 0.88 percent of the total cherries. The second measure shows the increase in percentage of defects removed; for example, 9.7 percent more of the major defects were removed when using the chromatic illumination. The third measure shows the magnitude of improvement in percentage. For example, a sorting efficiency of 28.4 percent is an improvement of 51 percent over a sorting efficiency of 18.7 percent.

IMPORTANCE OF BACKGROUND

Since the color and lightness of the background influences the adaptation of the eye, reflectance curves were established for the three common belt colors (white, tan, and black) used in cherry processing plants. The optimum adaptative condition is to have uniform field lightness; that is, lightness of background equal to the lightness of the product.[4] It was found that the white belt reflected too much light and resulted in a high level of adaptation for the eyes. With this high level of adaptation it would be difficult to detect dark defects on red cherries, especially when white illumination is used. For the chromatic illumination discussed above the adaptation level is reduced somewhat, but the white belt is still too light for maximum visibility of cherry defects. When using filter B-23 over the illuminant, the tan belt seems to be a good choice, but for white illumination the black belt is preferred.

VIEWING THE ENTIRE CHERRY SURFACE

As mentioned previously, viewing the entire cherry surface is essential to high sorting efficiency. Because of the importance of this factor, two devices were developed and tested for rotating cherries at intervals along the sorting belt.

[4]This applies to sorting where lightness contrast is the major factor in visibility difference.

ROTATING ROD

A steel rod wrapped with friction tape (7/16 inch overall diameter) was mounted across the belt and rotated to cause the cherries to go over it (Fig. 2). The peripheral velocity of the rotating rod ranged from 25 to 60 feet per minute. The belt velocity was 24 feet per minute. Cherries were placed on the belt, one layer deep in front of

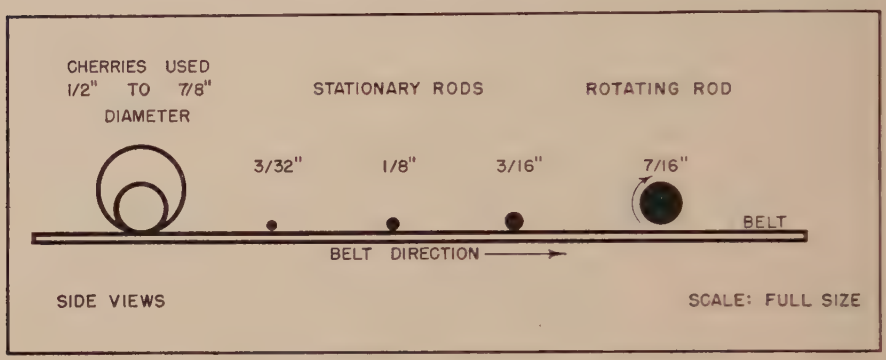

Fig. 2. Devices for rotating cherries on sorting belt.

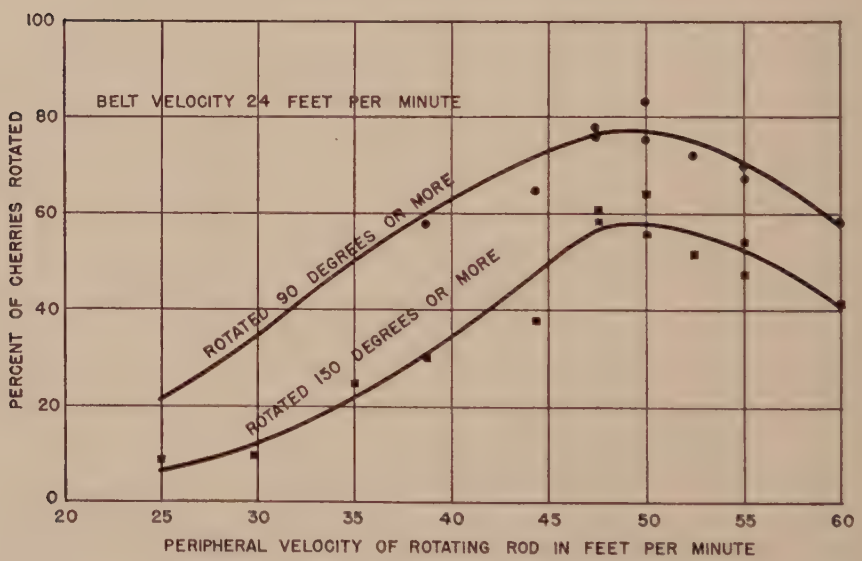

Fig. 3. Rotation of cherries on sorting belt with a rotating rod.

the roller and white paint was used to mark two rows of 50 cherries each across the belt. The paint dried in 1 to 2 minutes; then, the belt was started. When both test rows had passed over the rod the belt was stopped and a count was made of all the cherries rotated 90 degrees or more and those rotated 150 degrees or more.

The efficiency of the rotating rod is shown by two curves in Fig. 3 which give the percentage of cherries rotated 90 degrees or more and the percentage of those rotated 150 degrees or more. The maximum efficiency was 80 percent of the cherries having been rotated 90 degrees or more and 60 percent rotated 150 degrees or more. The peripheral velocity of the roller was twice the belt velocity at maximum efficiency.

STATIONARY RODS

Tests were conducted on three sizes of smooth stationary rods which were mounted across the sorting belts. Tests showed that the 3/32-inch rod was inefficient; therefore, it was eliminated. The data for the 1/8-inch and 3/16-inch rods are shown in Fig. 4 which illustrates how the rotation of cherries varies with the belt velocity and the percentage of the belt covered with cherries. These curves show

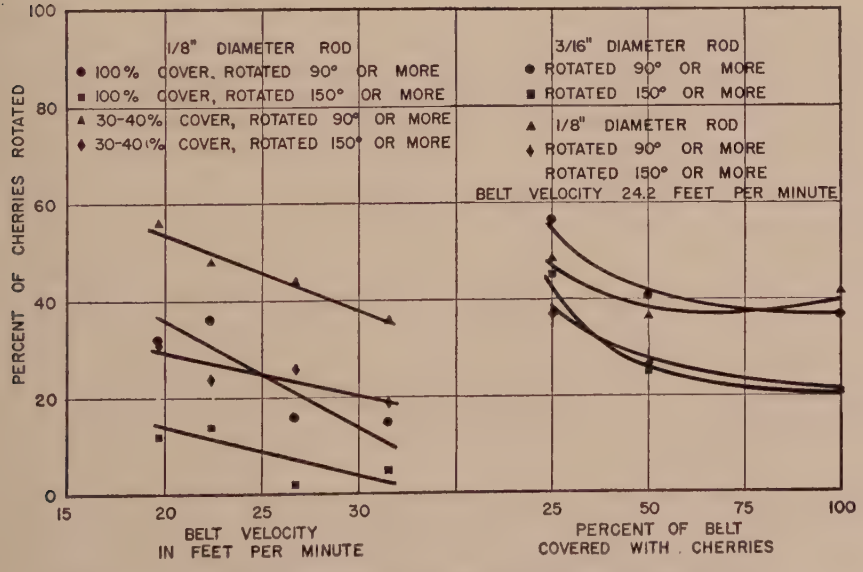

Fig. 4. Rotation of cherries on sorting belt wtih a stationary rod.

that the efficiency decreases as the belt speed increases and as the concentration of cherries on the belt increases. At maximum efficiency approximately 55 percent of the cherries were being rotated 90 degrees or more and 45 percent being rotated 150 degrees or more.

OTHER FACTORS

Several other factors were investigated in connection with the foregoing research. The following statements appear significant:

1. Black and brown defective spots on cherries do not fluoresce when exposed to radiation of a high-pressure mercury vapor lamp which possesses a group of spectral lines near 365 millimicrons.

2. Seemingly cherries can be sorted by transmitted light; however, the intensity of illumination required is rather high. Sorting by transmitted light gives somewhat the same appearance as the use of filter B-23.

3. Specular gloss from cherries may be minimized by using diffuse illumination. This should improve perception and ease eyestrain.

CONCLUSIONS AND SUMMARY

This study concerns the sorting efficiency of workers in cherry processing plants as affected by the spectral distribution of the illuminant, the reflectance of cherries and their defects, and the rotation of cherries on the sorting belt. Analysis of the visibility of cherry defects revealed that the main visual differences in the cherries and defects were due to lightness differences. Hue and saturation differences were of relatively minor importance. Based on that information, calculations were made to determine the possibility of increasing the contrast ratio, which is used as a measure of lightness contrast. Field tests were then conducted in three cherry processing plants for comparison of chromatic to white illumination. The analysis and field tests on chromatic illumination and rotation of cherries lead to the following statements:

ILLUMINATION FOR SORTING

1. The lightness contrast between dark defects and red tart cherries can be increased by selecting the spectral distribution of the

illuminant. For under-color defects the lightness contrast can be increased only slightly by changing the spectral distribution of the illuminant.

2. The 2910° K tungsten lamp (approximately the spectral distribution of the 150-watt incandescent bulb) produces the greatest lightness contrast for dark defects of illuminants considered when used without a filter. (See Table 1 for illuminants.)

3. The G. E. deluxe warm white fluorescent lamp without a filter is the most efficient of the lamps considered in producing reflected luminous flux from the cherry surface; that is, it possesses the highest efficiency when one uses lightness of the cherry surface as the measure of efficiency.

4. Statements "2" and "3" also apply when using certain low-cost gelatine filters over the illuminants (Table 1).

5. For theoretical filters, which perfectly absorb or transmit, the deluxe warm white fluorescent lamp possesses considerable advantage in illuminant efficiency for the same lightness contrast of dark defects as obtained with the 2910° K tungsten lamp.

6. Red illumination produced by covering the illuminant with filter B-67 was unsatisfactory because some workers complained of headaches and eyestrain when using red illumination. Whether these complaints were due to psychological reactions or to physiological effects was not determined.

7. In general, illumination provided by covering the illuminant (G. E. deluxe warm white fluorescent or 150-watt incandescent filament lamps) with the purple filter, B-23, was favorably received by the workers.

8. The most favorable adaptive condition was to have a uniform field lightness—lightness of product, background, and surround being equal. In this respect a background darker than the product is preferable to one which is lighter.

ROTATION OF CHERRIES ON SORTING BELT

The merits and application features of the devices used for rotating cherries on sorting belts are listed as follows:

1. The stationary rod must be mounted closely against the belt in order to prevent cherries from being caught underneath it. To insure contact on most sorting belts it would be necessary to support the belt underneath the rod.

2. The stationary rod has the disadvantage of interfering with the passage of the belt lacing. It may be necessary to provide endless belts if this device is employed.

3. The maximum efficiency obtained with the stationary rod was 55 percent of the cherries being rotated 90 degrees or more and 45 percent being rotated 150 degrees or more. The efficiency decreased as the belt velocity increased and as the percentage of belt covered with fruit increased.

4. The efficiency obtained with use of the rotating rod may reach 80 percent of the cherries being rotated 90 degrees or more and 60 percent being rotated 150 degrees or more. These tests were made with the belt completely covered with cherries.

5. The rotating rod requires a driving mechanism.

6. The rotating rod used in the tests was mounted approximately 1/16 inch above the sorting belt. It did not interfere with the passage of the belt lacing.

7. With a coating of black friction tape on the rotating rod, the maximum efficiency of rotation was reached when the peripheral velocity of the rod was twice the belt velocity.

RECOMMENDATIONS

The results of this study lead to the following recommendations for improving the efficiency of workers who are sorting red tart cherries for defects.

1. A satisfactory illuminant for producing high lightness contrast for dark defects[5] is one which will produce at least 180 footcandles on the belt by use of tungsten lamps or 300 footcandles by use of G. E. deluxe warm white fluorescent lamps. Cover the lamps with filter B-23 or other apparently satisfactory filter (see test). (Note that only B-23 has been tested in the field and found to be free of any serious criticism on the part of the workers.) Laboratory observations indicate that increasing the illumination beyond these limits will increase somewhat the visibility of the dark defects. For under-color defects the daylight fluorescent lamp is the most satisfactory of illuminants considered from the point of view of illuminant efficiency and lightness contrast.

2. There should be some general illumination in the room, although, if this illumination becomes too high, it will decrease the

[5]Dark defects are defined as defects which are darker than brown rot.

lightness contrast of dark defects and adapt the eyes to a higher level of illumination, which would be detrimental. An estimate of a satisfactory level of illumination in the plant is from 5 to 15 footcandles.

3. Reflectance curves for the common belting materials (white, tan, and black) used in cherry processing plants show that the black belt most nearly satisfies the requirements for uniform field lightness for white illumination. For illumination produced by using filter B-23 over the illuminant, the tan belt appears most desirable. Also, the fruit guards and the worker's clothing should not have high reflectance; the importance of this is minimized since less illumination will usually fall on the clothing. No bright illuminants should be in clear vision of the workers.

4. If the processor desires to remove the under-color defects, the G. E. Daylight fluorescent illuminant could be placed at the end of the sorting belt and a partition placed between it and the chromatic illuminant.

5. It is recommended that devices for rotation of cherries be located in each space between workers on the sorting belt or at other suitable intervals. The statements pertaining to application, listed in the conclusions, may be used as a guide for selection and installation.

SOME EFFECTS OF ACCELERATED ELECTRONS OR CATHODE RAYS ON CERTAIN INSECTS AND ON THE WHEAT AND FLOUR THEY INFEST

PART II

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THIS REPORT is a continuation of a paper by Baker, Taboada, and Wiant (1953) in which was discussed the purpose of tests, review of literature, a description of the Van de Graaff electron accelerator, units of radiation dosage, method of testing, and results of baking and germination tests. It is recommended that Part I of this paper be reviewed before Part II is studied.

The object of Part II is to present further information on dosage calculation, penetration of electrons into sample, temperature rise in the sample, and culture of insects for tests, and to report further information on the effects of accelerated electrons on wheat, flour, and beans as well as the effects on certain insects which infest those commodities.

METHOD OF CALCULATING DOSAGE

The method used for calculating dosage of ionizing electrons was essentially the same as that presented by Trump *et al.* (1948). Their formula for dosage calculation is:

$$P = \frac{EI}{\pi\left(\frac{D}{2}\right)^2 R} \qquad K_1K_2 = \frac{4\,EI\,K_2}{\pi\,D^2} \cdot \frac{K_1}{R} \quad \text{watts per gram}$$

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where: P = power absorbed per gram of material distributed evenly over container of diameter D in centimeters.

E = accelerating voltage
I = total beam current to container of diameter D
R = depth of material in grams per square centimeter
K_1 = fraction of total power absorbed in range R
K_2 = back scatter factor

The value of K_1 may be obtained for 2, 3, 4, and 5 Mev (million electron volts, see Part I for definition) electrons from Fig. 1 by dividing the area under the curve for a sample thickness R in grams per square centimeter by the total area under the curve for a given Mev. K_1 and K_1/R have been calculated for 2 Mev electrons by using this method (Fig. 2) and are used at the radiation laboratory of The Upjohn Company for calculating dosages of 2 Mev electrons. The data in Fig. 1 are based on published data for aluminum. Since R is in grams per square centimeter, these curves can be used for most homogenous materials. Trump (1948) points out that K_2 can be kept close to unity by irradiating the sample in a dish made of a material having a low atomic number. Before an actual dosage problem is solved, it will be desirable to know the penetration of accelerated electrons into the materials to be irradiated.

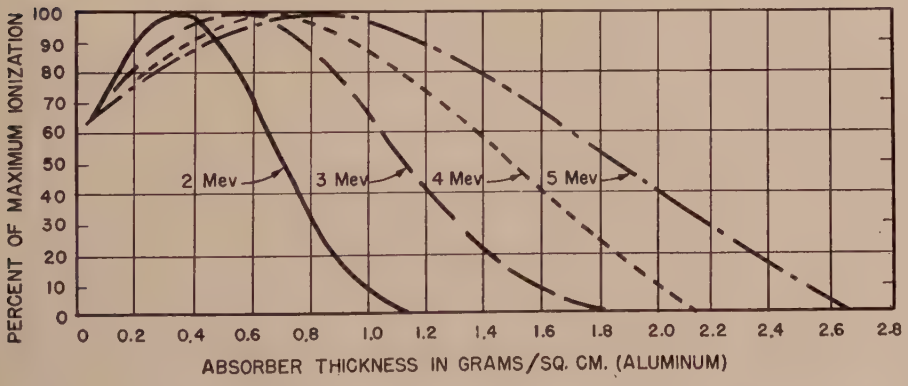

Fig. 1. Percent of maximum ionization for 2, 3, 4, and 5 Mev electrons in aluminum.

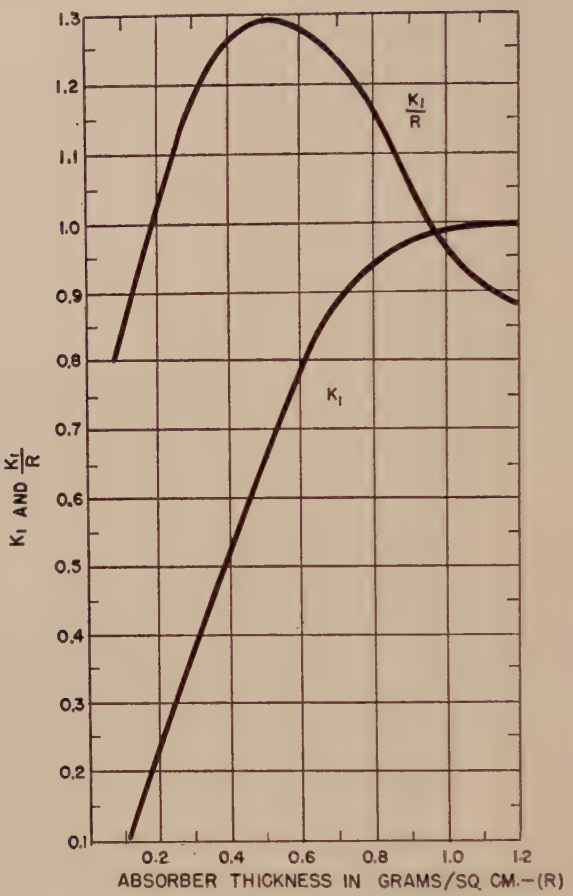

Fig. 2. $\frac{K_1}{R}$ and K_1 for calculating the dosage of 2 Mev electrons.

PENETRATION OF ELECTRONS INTO WHEAT AND FLOUR

In order for electrons to be effective in ionizing tissue and thus causing lethal effects, the energy of the electrons must be absorbed by a material while the electrons travel through the material. Knowing the actual penetration depths of accelerated electrons into a material is of little value unless some information is available on how the energy is dissipated in the material. The percentage of the maximum ionization curve for 2 Mev electrons for wheat (Fig. 3) was calculated

from the 2 Mev ionization curve of aluminum in Fig. 1, using a density of 0.74 gram per cubic centimeter for wheat and flour.

It is important to note that, although the ionization curves in Fig. 1 were determined for aluminum, these same curves may be used for other materials. This is because depths of material in R units (grams/per square centimeter) are independent of the type of material. Therefore, when the curves in Fig. 1 have been established, the depth in inches or centimeters of penetration of accelerated electrons into materials other than aluminum may be calculated.

The depth of penetration in inches of 2 Mev electrons into wheat or flour may be calculated by using a density of wheat or flour of 0.74 gram per cubic centimeter and by assuming that the layer of wheat or flour is to receive 60 percent of the ionization dose on the top and bottom of the layer. From Fig. 1 the value of R which satisfies these conditions is 0.65 gram per square centimeter. In order to convert to inches of wheat or flour the value 0.65 is divided by 0.74 (gram per cubic centimeter, the density of wheat or flour) which gives the depth in centimeters. By dividing this result by 2.54 (centimeters per inch), the depth in inches is obtained, as illustrated in the following example:

$$\frac{0.65}{(0.74)\quad(2.54)} = 0.35 \text{ inches of wheat or flour}$$

This same procedure may be used for any material by selecting the desired value of R and dividing by the density of the material.

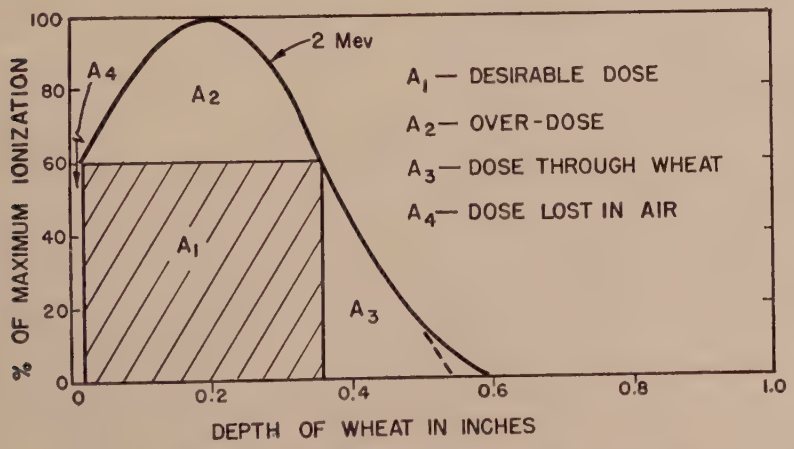

Fig. 3. Depth of penetration of 2 Mev accelerated electrons in wheat (density 0.74 gram per cubic centimeter) with 60 percent of maximum ionization at top and bottom layer of wheat.

CHOICE OF PERCENT OF MAXIMUM IONIZATION ENTERING AND LEAVING SAMPLE

It is desirable to choose a thickness of sample so that the percent of maximum ionization at the top and bottom of the sample is the same. The percentage of maximum ionization for 2 Mev electrons in wheat is shown in Fig. 3. A dose of 60 percent of maximum ionization was chosen for this figure. The physical shape of this curve shows that the maximum ionization occurs below the surface of the material irradiated. This apparently is due to the fact that electrons and other ionizing particles give up more energy per differential path length as their energy becomes less (down to a certain limit). The area A_1 represents the desirable dose, A_2 the over-dose, A_3 the dose lost through the sample, and A_4 the dose lost in the air above the sample. The ideal dose, A_1, should be a value such that A_1 is a maximum, with the sum $A_2 + A_3 + A_4$ being a minimum. This condition is approximately satisfied when the electrons on entering and leaving the sample produce 60 percent of the maximum ionization in the sample. Maximum energy can be transferred to the sample—i.e., K_1 R is a maximum in equation (a) and Fig. 2 for 2 Mev electrons—by using a depth of product between 0.4 and 0.65 gram per square centimeter, as an upper limit of depth for 2 Mev electrons. This would be approximately 0.35 inch of wheat or flour.

If wheat or flour is irradiated on a conveyor belt and 60 percent of maximum ionization is to be obtained in the top layer of flour and in the layer of flour next to the conveyor belt, then the maximum depth which can be treated is about 0.35 inch for 2 Mev electrons, and about 0.57 inch for 3 Mev electrons. These depths may be increased when the material is irradiated from both top and bottom. If one assumes 60 percent of maximum ionization in the top and bottom layers and neglects losses in the conveyor belt, calculations will show that a depth of approximately 0.9 inch of wheat or flour can be treated if irradiated from the top only with 5 Mev electrons (Fig. 4) or a depth of more than 2.0 inches can be treated if irradiated from top and bottom with 5 Mev electrons.

FURTHER INFORMATION ON DOSAGE CALCULATIONS AND RATE OF TREATMENT OF PRODUCT

An example of the calculations used to obtain the exposure time for a dose of 1,000,000 rep of 2 Mev electrons in a stationary 9-centi-

meter diameter sample is presented. By definition, 1×10^6 rep=8.38 joules/gram of tissue. Assume that the beam current is 50 microamperes and that the depth of wheat or flour chosen to be irradiated is about 0.65 gram per square centimeter (from Fig. 1). Then from Fig. 2,

$\frac{K_1}{R} = 1.25$, assume $K_2 = 1$. Then from equation (a)

$$P = \frac{4\ (50 \times 10^{-6})\ (2 \times 10^6)\ 1}{\pi\ (9)^2}\ (1.25) = 1.96 \text{ watts/gram} = 1.96$$

Joules per second-gram.

The time required to deliver an average dose of

$$1 \times 10^6 \text{ rep is } \frac{8.38 \text{ joules per gram}}{1.96 \text{ joules per second-gram}} = 4.27 \text{ seconds}$$

By the same formula, with the same conditions, the time required for 500,000, 100,000 and 10,000 rep is 2.13, 0.427, and 0.0427 seconds respectively.

It should be pointed out here that in this paper, when calculating the dose of accelerated electrons on insects, the density of the insect was assumed to be 0.74 gram per cubic centimeter when the insects were mixed with flour and wheat, and an insect density of 1.0 was assumed when the insects were irradiated in plain dishes with no flour.

By knowing the time required to administer a given dose to a stationary sample, it is a simple matter to calculate the belt speeds for products to be treated on a conveyor belt. In actual practice, the belt speed may be set, which in turn would set the exposure time. If this is the case, then the beam current could be adjusted to obtain the desired dose in rep.

Suppose that it is desired to calculate the rate of flow of wheat or flour receiving a dose of 100,000 rep. Assume that a 2-Mev generator is available and that 200 microamperes of beam current is dissipated in the wheat. This would be 400 joules per second or a power

of 400 watts. If one uses the value of 0.838 joule per gram for 10^5 rep, then the rate of flow is about:

$$\frac{400 \text{ joules per sec.}}{0.838 \text{ joule per gram}} = 478 \text{ grams per second or}$$

$$\frac{478 \ (60) \ (60)}{453.9} = 3800 \text{ pounds per hour}$$

If the dosage is reduced to 10,000 rep, the rate of flow would be about 38,000 pounds per hour.

Table 1 lists formulas which may be used to calculate the rate of flow of wheat and flour (density 0.74 gram per cubic centimeter) receiving dosages of 2, 3, 4, and 5 Mev electrons. The depths in Table 1 were obtained from Fig. 4. By the use of the formulas in Table 1, various conveyor belt widths (W in inches) and belt speeds (S in feet per minute), may be used to calculate a desired flow rate;

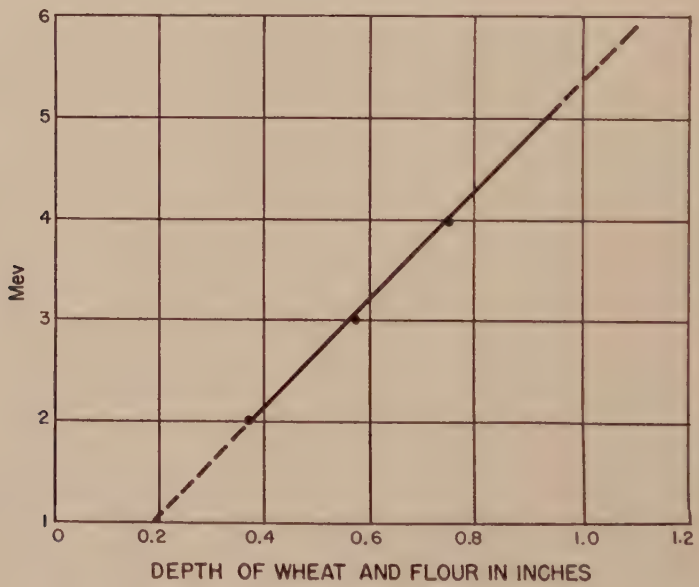

Fig. 4. Depth of penetration of accelerated electrons in wheat and flour (density 0.74 gram per cubic centimeter) with 60 percent of maximum ionization at the top and bottom of the irradiated layer.

TABLE 1—Formulas for calculating rate of treatment of wheat and flour on a conveyor belt with W as the width of conveyor belt in inches, and S as the speed of conveyor belt in feet per minute

Depth in inches	Mev.	Rate of flow formula
0.35	2	WS x 6.8 = lb./hr.
0.57	3	WS x 11.2 = lb./hr.
0.75	4	WS x 14.7 = lb./hr.
0.94	5	WS x 18.4 = lb./hr.

or if the flow rate is set, the width and speed of the belt may be calculated. When the rate of flow has been established, the beam current may be adjusted to give the desired dose in rep.

At 2c per KWH, the cost of electric energy for a dose of 1×10^5 rep at an efficiency of 10 percent, is about:

$$\frac{400 \text{ watts} \times 1 \text{ hr.}}{1000 \times 0.10} \times \frac{2}{\text{KWH}} \times \frac{3800}{2000} =$$

15.2 cents per ton or 0.76 cents per 100 pounds

With a dose of 10,000 rep, the cost of energy is about 1.52 cents per ton.

THE DISTRIBUTION OF CURRENT DENSITY

Curves for the distribution of 2 Mev cathode rays in a traverse plane 40 centimeters from the 3-mil aluminum window for the Van de-Graaff electron accelerator have been presented by Trump (2). Data from these curves enable one to calculate the maximum and minimum doses distributed across a given sample. The distribution of the dose across the object may be controlled by selecting the thickness of the scattering window, the absorber depth, and the irradiation distance. The thickness of the scattering window installed in the 2 Mev Van de-Graaff electron accelerator at The Upjohn Company was chosen so that the distribution of the unscanned cathode ray beam across the samples being irradiated was rather uniform.

CALCULATIONS FOR TEMPERATURE RISE IN A GIVEN SAMPLE

To calculate the temperature rise in a given material receiving a dose of accelerated electrons, the following formula is used:

$$Q = W\,(s.h.)\,(T_2 - T_1) \qquad (b)$$

Where Q = the energy required to heat material of weight W and specific heat (s.h.) from an initial temperature T_1 to a final temperature T_2. Suppose it is desired to calculate the temperature rise for 1 gram of wheat or flour receiving a dose of 100,000 rep using equation (b) and a value of Q = 100,000 rep = 0.20 calories per gram and s.h. = 0.4. By definition 1 rep = 83.8 ergs per gram; then, since 1 Joule = 10^7 ergs and 4.186 Joules = 1 calorie,

$$100{,}000 \text{ rep} = \frac{0.838 \text{ Joule per gram}}{4.186 \text{ Joules per calorie}} = 0.20 \text{ calorie per gram}$$

and:

$$T_2\text{-}T_1 = \frac{Q}{W\,(s.h.)} = \frac{0.20}{0.4(1)} = 0.5^\circ \text{ C. temperature rise}$$

The temperature rise for 1 gram of flour receiving a dose of 500,000 rep would be about 2.5° C.

TESTS CONDUCTED

Ten tests were conducted, using the Van de Graaff electron accelerator. These tests include germination tests and irradiations for the wheat and flour later used in the baking tests (see Part I). Insects were irradiated in the first seven tests. The procedure for each test was similar, a general description of procedure was presented in Part I with a specific procedure for two tests. This description will suffice, since the procedure given, together with the tabulated data for each test by Baker (1953) and Taboada (1953) will enable one to repeat the tests.

The insects for all tests were grown in a constant-temperature, constant-humidity incubator in the Entomology Department at Michigan State College (Fig. 5), and samples for each series of tests were prepared in the Entomology Laboratory (Taboada, 1953). After

Fig. 5. View of a constant-temperature, constant-humidity oven used to incubate insects. Saturated NaCl solution was maintained in the bottom of oven in order to give 70 percent relative humidity at 75° F.

preparation, the samples were placed in an insulated box and transported by automobile from East Lansing to The Upjohn Company at Kalamazoo, Michigan. The samples were then irradiated and returned to East Lansing the same day and again placed in the incubator. Observations were made at intervals after each test.

FURTHER RESULTS

Results of the tests conducted, using the granary weevil and flour beetle, were presented in Part I. Tests conducted, using Michigan navy beans infested with the bean weevil (*Acanthoscelides obtectus,*

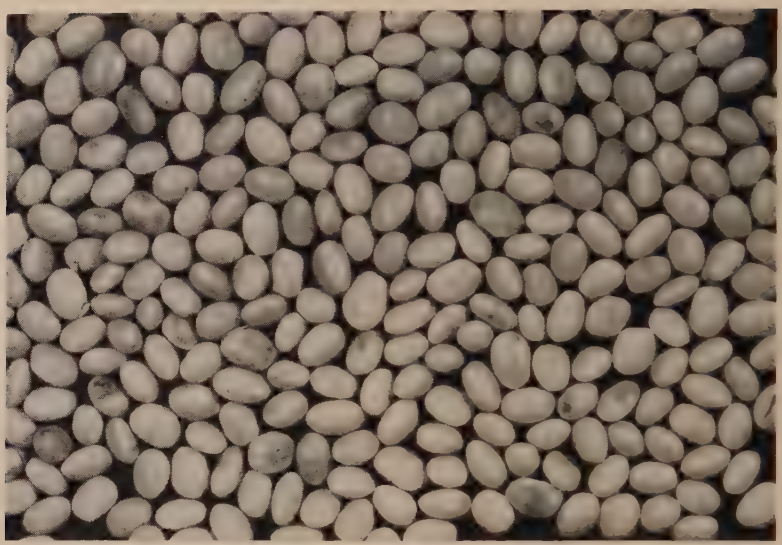

Fig. 6A. Beans artificially infested with bean weevils and irradiated with an accelerated electron dose of 100,000 rep from the 2-million-volt Van de Graaff electron accelerator. Picture taken after an incubation period of about 43 days from date of treatment.

Fig. 6B. Beans artificially infested with bean weevils used as a check sample (untreated). Picture taken after an incubation period of about 43 days from date of treatment of sample shown in Fig. 6A.

Fig. 7. Growth of untreated (left) and treated Michigan navy beans (right) 2 weeks after planting in greenhouse.

Say), show that an electron dose of 10,000 rep was lethal to 100 percent of adult bean weevils, 1 week after treatment. Fifteen adult bean weevils were irradiated for each test. These adults were irradiated in 9-centimeter diameter petri dishes containing 20 grams of Michigan navy beans. An electron dose of 100,000 rep was lethal to 73 percent of the adults 48 hours after treatment, and to 100 percent of adults 1 week after treatment.

Samples of artificially infested Michigan navy beans which received a dose of to 1×10^5 rep and a sample used as a check (untreated), as they appeared after an incubation period of about 43 days, are shown in Figs. 6A and 6B. These pictures show that a dose of 1×10^5 rep is sufficient to prevent the insect from damaging the beans.

The growth of treated and untreated Michigan navy beans, 2 weeks after planting in a greenhouse, is shown in Fig. 7. This picture shows that a dose as low as 10,000 rep was detrimental to bean seed.

EFFECT OF ACCELERATED ELECTRONS OR CATHODE RAYS ON VITAMINS

Some effects of accelerated electrons and X-rays on vitamins and enzymes have been reported by a number of investigators. Proctor and Goldblith (1948, 1949) reported that niacin in a concentration of 100 micrograms per milliliter was not destroyed by X-rays in total

dosages between 125,000 and 850,000 roentgens (r). The amount of destruction of niacin by cathode rays increased with dilution. Goldblith and Proctor (1949) reported that there was no appreciable effect of a dose of 10,000 rep on a 100 micrograms per milliliter solution of riboflavin and carotene. When treated with a dose of 100,000 rep, there was about 95 percent retention of riboflavin with the same dilution as above. There was only 40 percent retention of riboflavin and about 65 percent retention of carotene when this same percentage of solution received a dose of about 500,000 rep. Other important observations on the percentage retention of riboflavin were made also by Goldblith and Proctor (1949).

These same investigators report the retention of 98 percent of a 100-microgram-per-milliliter solution of ascorbic acid when irradiated with an X-ray dose of 10,000 rep, whereas only 37 percent of the ascorbic acid in a 100-microgram-per-milliliter solution was retained when irradiated with a dose of 100,000 rep.

Brash (1949) reported no loss of activity when the enzymes trypsin, pepsin, and papain were irradiated with a dose of 3×10^6 rep of accelerated electrons. The enzyme diastase from barley showed a 14-percent loss in activity when irradiated with a dose of 9×10^5 rep. The enzyme urease from soy flour showed a loss of 14 percent when irradiated with a dose of 2×10^6 rep. The loss in activity in other enzymes, when irradiated with dosages up to 8×10^5 rep was reported by Brash, *et al.* (1949), but in no case was the loss in activity greater than 15 percent. All of the foregoing doses reported were greater than necessary for insect control in wheat, flour, and beans. The loss in enzyme activity should be less with reduced doses.

When accelerated electrons are used to sterilize food certain side-effects may be produced which may cause changes in color, flavor, and sometimes texture. Studies have been made by Proctor *et al.* (1952) in an effort to minimize these changes. Irradiation of materials in inert atmospheres or in a vacuum and in the frozen state minimizes but does not prevent such changes. Most of the dosages used by Proctor and his associates were for microorganism control and are much higher than those required for insect control.

SUMMARY

Further information on the effects of accelerated electrons on insects which infest wheat, flour, and beans is presented, as well as information on the method used to calculate dosage, penetration of

electrons into wheat and flour, rate of treatment of products, cost of electrical energy for a given dose in rep, distribution of current density, calculation of the temperature rise in a given sample, and a review of literature on the effects of accelerated electrons on vitamins and enzymes.

The use of accelerated electrons to stop adult insects from reproducing and to sterilize insect eggs in wheat, flour, and beans offers promise for insect control. However, this process is still in the experimental stage. Further research is necessary before it can be recommended for industrial use.

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INHERITANCE OF EGG WEIGHT AMONG PARENTS AND PROGENY OF A DARK CORNISH-WHITE LEGHORN RECIPROCAL CROSS

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EVIDENCE that egg size as measured by weight is inherited is generally accepted, although Jull[1] in a review of the subject has cited a number of controversial questions on the mode of inheritance, including:

1. Is egg weight sex-linked?
2. Is large egg size dominant?
3. Does the dam have more influence than the sire on the inheritance of egg weight?

EVIDENCE FROM CROSS BREDS

Evidence that might help to answer some of the afore-mentioned questions could be obtained in a number of ways, but the evidence to be offered herewith was obtained from experimental cross matings of two breeds which differed decidedly in egg weight.

The results obtained were as follows:

1) Egg weight behaved genetically as an ordinary quantitative or multiple-gene characteristic; 2) it was not sex-linked, and 3) the dam had no more influence than the sire on its inheritance, as determined by statistical analysis of egg weights of reciprocally cross-bred F_1 progenies.

UTILITY OF RESULTS

For one to make best use of experimental results in breeding practice, the average egg weight of the different populations should be regarded merely as a base point for reference and not as a goal. Selection from the average of families cannot be expected to increase the

[1]Jull, M. A. (1952). *Poultry Breeding.* John Wiley and Sons, New York. 398 pp.

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number of above-average individuals. This experiment shows approximately how much above the average that the selection standard should be for improvement.

The probable number of genes involved could not be estimated from the data, but the possibilities when two different egg weight populations are crossed are shown. Breeding results obtained from the use of a well known statistic, the standard deviation, will be demonstrated herein.

METHODS OF OBTAINING THE EVIDENCE

It is generally recognized that the effects of genes in quantitative inheritance are not so apparent in individuals as are those of unit character genes such as comb type or plumage color. The genetic components of quantitative characteristics can only be estimated by measured performance of populations of individuals. For example, an individual hen may lay a single egg which weighs 60 grams, but experience has shown that there is considerable variation in the weight of eggs that this same hen may lay. Hens of the same breed or breeding differ also in egg weight characteristics. In order to identify genetic potentialities it is necessary to measure the performance of *populations* of hens of similar egg-weight characteristics, and to segregate and breed such populations until the limits of the character are established. Such a procedure was followed in general at this station to obtain the results reported herein.

PARENTAL GENERATIONS

The parental generations consisted of two breeds: Dark Cornish and White Leghorn. The average egg weights of the two separate populations are shown in Table 1. The populations were composed of random samples of the breeds on the College Poultry Farm in 1942 at the start of the experiment. That the two parental populations differed significantly with respect to average egg weight was statistically established. The difference is clearly evident in Fig. 1. The average egg weight of 50 individual Dark Cornish parents was 51 grams[2] and that of the 100 White Leghorn parents averaged 57 grams. The average of 50 reciprocally cross-bred F_1 progeny was 55 grams, which was approximately intermediate between the averages of the two parental populations.

[2] 28.3 grams = 1 ounce (approximately).

DIFFERENCE IN NUMBERS

It was evident at the beginning of this experiment that there would be a difference in numbers between the various populations. The reasons for those differences should be apparent to all who are familiar with the normal variation in biological behavior of chickens. No one can predict just how many individual chickens will survive an experiment and how many of those which survive will register a particular characteristic. In the usual histogram chart it is customary to indicate the numbers of individuals in each class. Since the total numbers in the various populations differed materially in this experiment it seemed desirable to compare the percentages of the total populations in the several classes instead of the totals. The totals can be calculated easily from the graphs.

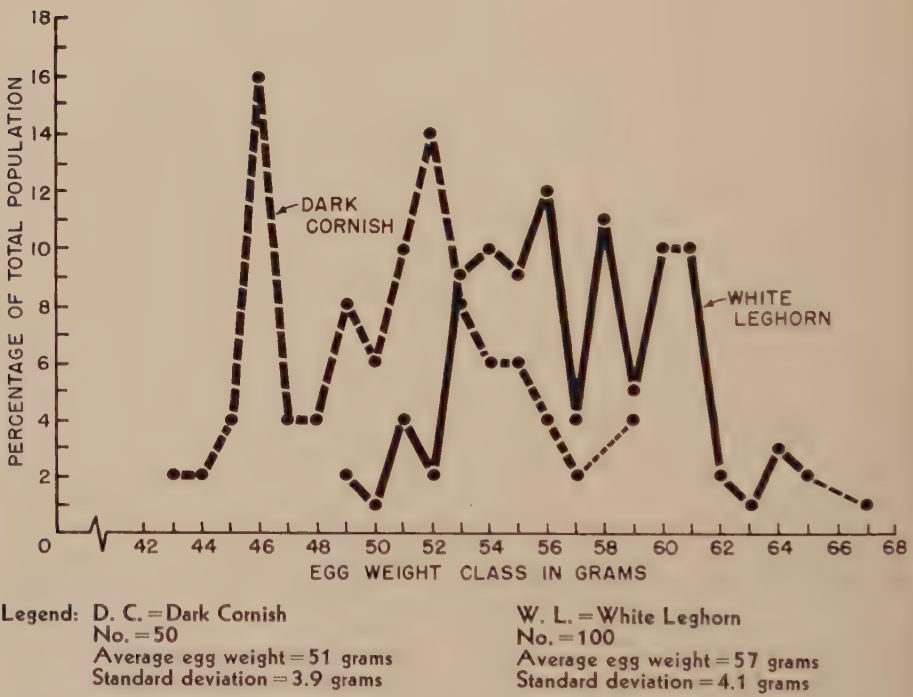

Fig. 1. Percentage of total egg weight populations in various egg weight classes.

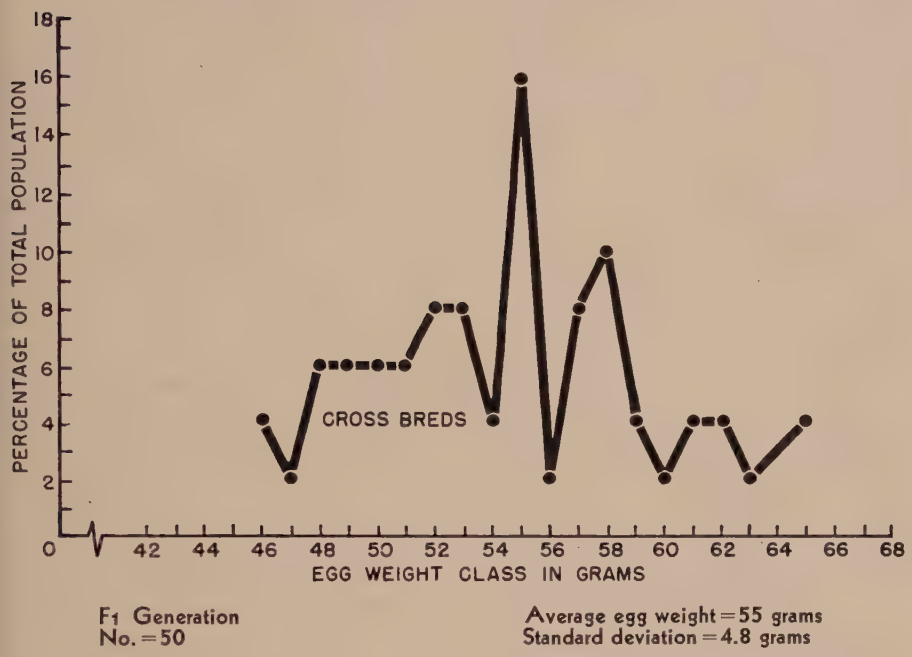

Fig. 2. Percentage of total egg weight population in various egg weight classes.

METHOD OF DETERMINING AVERAGES

There is difference of opinion as to how inherent egg weight should be designated. Henderson[3] and many others earlier have shown that egg weight during the pullet year varies seasonally, but that "adult" egg weight is very nearly attained during the spring months, March, April or May.

For genetic and statistical purposes it was desirable to establish a uniform method of designating an individual inherent egg weight index. The criterion should be such that individual pullets cannot exert an unequal influence on the average of the population. In this report, the method adopted was to calculate the average weight of a sample of the eggs laid by each individual randomly selected pullet during the months of March, April and/or May. The individual egg weight averages or indices were then used as units (variants) to determine the population averages shown in Figs. 1 and 2. Since there were unequal numbers in the different populations, the population shown

[3]Henderson, E. W. (1938). Monthly weight changes of White Leghorn pullets in relation to concurrent egg weight and rations. Growth 2: 267-278.

in each curve in Fig. 1 was derived by plotting the percentage of the total population falling in each egg weight class. For example, in the Dark Cornish population there was one pullet having an egg weight index of 43 grams (2 percent), two of 45 grams (4 percent) eight of 46 grams (16 percent) etc. This method of illustration permits visualization of the distributions of egg weight. The graphs of the population distributions provide evidence which is not apparent from the usual statistical treatment such as the ordinary analysis of variance tables.

APPARENT MODALITY

It seems apparent that there are two peaks or modes in the curve of the Dark Cornish parental population, but the number of individuals was considered insufficient to permit a satisfactory statistical verification. The F_1 population curve resembles that of an F_2 trimodal distribution characteristic of the multiple-factor type in which two pairs of genes are involved. Unfortunately, the experimental facilities did not permit retention of F_2 populations of appreciable size from the crosses. Since a statistical method for estimating the number of genes involved is based on comparison of the distribution of the F_1 population with that of the F_2, the data are inadequate for that particular purpose.

SOME PRACTICAL APPLICATIONS

Although the probable number of genes involved could not be estimated from the data, evidence of what to expect when two different egg weight populations are crossed is clear. It seems clear also (Table 1) that neither dominance nor "hybrid vigor" can be relied on to bring the egg weight of a relatively deficient population such as the Dark Cornish up to that of Leghorns in a single generation. The standard deviation statistic should have utility as a guide in selection for the improvement of egg weight.

TABLE 1—Statistics of populations by breed

	Dark Cornish	White Leghorn	F_1 Reciprocal cross
Number	50	100	50
Average egg weight, grams	51	57	55
Standard deviation (S.D.)	3.9	4.1	4.8

STANDARD DEVIATION IMPORTANT

In choosing stock for breeders it is important to consider the standard deviation of the performance of the population as well as the average. Since twice the standard deviation is approximately the customary basis for determining the significance of a deviation from the average, it is just as important as the average. In choosing hens as breeders for the improvement of egg weight it is important to select those which have average egg weight more than twice the standard deviation from the average of the population if possible. The choice of males must necessarily be made more or less blindly at best, since the potentialities of a male must be estimated from the performance of his female relatives. The performance of the full sisters of a male should be a reliable predicting index of his probable genetic make-up.

TEST OF STANDARD DEVIATION AS A GUIDE TO SELECTION

In this study the importance of the standard deviation was shown by the relative egg weight performance of the progeny from the highest ranking hens of both parents which happened to have progeny in some cases by sires or dams of both breeds. Unfortunately there were only two of the doubly superior pairs of parents. Twelve pairs of parents, however, exceeded the average egg weight by 4 grams, which is approximately the standard deviation of both breeds. Unfortunately the hens were not always mated to males with a sister index above average in *their* respective breeds. In a few instances the males had no sisters from which a "spring" egg weight index could be estimated and the egg weight index of their purebred progeny was used instead. The average egg weight of the progeny of 12 superior pairs of parents is shown in Table 2 in comparison with that of the inferior parents, and that from "mixed" parents (i.e. only one of which was superior). The numbers in the classes were reduced very much by the elimination of those for which a sire and/or dam index could not be determined. The results in Table 2 agree in principle very well with those in Table 1. The effects of pedigree selection by means of the standard deviation as a guide are evident. The average of progenies of superior parents was 59 grams and that of the F_1 population was only 55 grams. Average egg weight of progeny from "inferior" parents was only 51 grams.

TABLE 2—Egg weight performance of progeny from "indexed" parental classes

	Parental class		
	Both superior index	Both inferior index	Mixed index
Number of pairs of parents	12.0	7.0	11.0
Average egg weight, grams	59.0	51.0	54.0
S. D., grams	5.0	3.4	4.3

SUMMARY

Spring egg weights of Dark Cornish-White Leghorn reciprocally cross bred pullet progenies were compared statistically with parental populations. Average egg weight of the populations was as follows:

1. Dark Cornish—51 grams (S. D. 3.9)
2. White Leghorn—57 grams (S. D. 4.1)
3. F_1 Reciprocal cross bred progeny—55 grams (S. D. 4.8)
4. W. L. $\times$ D. C. 54.8 grams. D. C. $\times$ W. L. 54.9 grams.

There was no significant difference between the mean egg weights of the reciprocal F_1 populations. Egg weight was not dominant, sex-linked, nor matroclinous. Heterosis was not evident. The superior value of the use of the standard deviation as a guide in selection practice over the population average alone was demonstrated.

INSECTS AFFECTING ALFALFA

By E. C. MARTIN
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CULTURAL methods were used almost entirely to control insects in legume fields prior to the advent of DDT during World War II. Since then chemical control methods have been used and have become more efficient and complex as new insecticides and new machinery have been developed.

Following extensive tests by research workers, the alfalfa seed growers of the western United States adopted spraying or dusting for insect control as a profitable practice in alfalfa seed production. In Michigan, Pederson[1] found that alfalfa seed yields could be increased by the use of insecticides. In Indiana, Wilson and Davis[2] dealt more comprehensively with the effect on seed production of controlling specific insects.

Recent research, particularly in Wisconsin, Indiana, Ohio and New York, has shown that the food value and quantity of hay and pasture can be seriously reduced when certain insects are abundant. The chemical control of these insects on pasture and hay crops is being rapidly accepted as practical and profitable. Work reported here is part of a comprehensive study of insects affecting alfalfa in Michigan. Measures for controlling some of the more important insect pests are given.

SURVEY OF INSECTS PRESENT IN ALFALFA FIELDS IN MICHIGAN

Sweeps in alfalfa were made with a 15-inch sweeping net on many different dates and in scattered locations in lower Michigan, during the late spring, summer and early fall of 1952 and 1953. Forty different species were noted in the collected material. Insects occurring consistently were *Lygus* spp.; *Adelphocoris lineolatus* (Goeze), alfalfa

[1]Pederson, C. E. (1948). Insecticides increase legume seed. Mich. Agr. Expt. Sta. Quart. Bul. 30: 298-308.
[2]Wilson, M. Curtis, and Ralph L. Davis (1953). Studies on chemical control of insects affecting alfalfa seed production. Proc. Ind. Acad. Sci. 1952. 62: 181-197.

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plant bug; *Adelphocoris rapidus* (Say), rapid plant bug; *Empoasca fabae* (Harr), potato leafhopper; other leafhoppers; *Philaenus leucopthalmus* Linn, meadow spittlebug; *Macrosiphum pisi* (Kltb.), pea aphid; other aphids and various grasshoppers. One field in Lapeer County was heavily infested with clover seed chalcid in September 1952.

STUDIES OF CHEMICAL CONTROL OF HARMFUL INSECTS ON ALFALFA

During 1952 chemical control of insects on alfalfa was studied on 25 plots measuring 25 feet × 80 feet with a 3-foot row between each plot. Plots were located at the north end of a 20-acre field of Ranger alfalfa[3] planted on the Michigan State College farm at East Lansing in August 1951. The field had not been mowed prior to the beginning of the studies reported. In 1953 the same 20-acre field was divided into 13 plots measuring 620 feet by 87 feet, each plot having an area of 53,940 square feet. The plots occupied almost the entire field.

SMALL PLOT STUDIES, 1952

On July 10, the plots were sprayed at the rate of 40 gallons to the acre with the amounts of actual insecticide shown in Table 1. Sprays were applied with a John Bean Spartan sprayer with a No. 3 nozzle, at 170-190 pounds pressure. Test plots were randomized and replicated

TABLE 1—Results of treatments as indicated by insect counts on July 12 and 17, 1952

Insect	Check	DDT 0.3 lb./A.	Chlordane 0.4 lb./A.	Toxaphene 0.5 lb./A.	Methoxychlor 0.6 lb./A.	Aldrin 0.15 lb./A.	Dieldrin 0.15 lb./A.	ET 30 Malathion Parathion 0.2 lb./A.
Adelphocoris rapidus and *A. lineolatus*	35	33	13	28	23	21	9	16
Lygus spp.	124	150	177	148	152	103	90	139
Aphids	307	268	210	226	148	170	100	130
Spittlebug—adults	277	218	202	234	132	188	122	148
Empoasca fabae and other leafhoppers	219	137	207	190	64	190	119	73

[3]Grateful acknowledgment is made to Prof. Byron H. Good for making available the alfalfa field used for these studies.

TABLE 2—Results of treatments as indicated by insect counts on August 6 and 12, 1952

Insect	Check	DDT 0.75 lb./A.	Chlordane 1 lb./A.	Toxaphene 1 lb./A.	Methoxychlor 1.5 lb./A.	Aldrin 0.4 lb./A.	Dieldrin 0.4 lb./A.	ET 30 Malathion Parathion 0.5 lb./A.
Adelphocoris rapidus and *A. lineolatus*...	18	11	4	10	5	7	6	4
Lygus spp.....	52	30	22	69	36	42	41	27
Grasshoppers.....	27	10	2	7	0	1	0	1
Spittlebug—adults....	341	159	86	218	80	203	100	119
Empoasca fabae and other leafhoppers...	313	171	410	144	81	304	441	456

three times. The plants were in the bud and early bloom stages. Following treatment, the plots were swept on July 12 and 17 during the mid-afternoon, by taking 10 standard sweeps lengthwise down the middle area of the plot. The field other than the plots was cut for hay on July 23; subsequently, there occurred an influx of grasshoppers and potato leafhoppers from the field to the plots. Alfalfa in the plots yellowed badly soon after the field was cut, apparently because of potato leafhopper damage.

Table 1 summarizes the results of total insect counts of all plots. Counts are on the basis of a total of 60 sweeps for each insecticide plot and check plot taken on July 12 and 17.

On July 31 the same plots were resprayed at the rate of 100 gallons to the acre. Materials and methods of application were repeated on the same plots. Plots were swept on August 6 and August 12. A summary of the results is shown in Table 2, with sweepings for the two dates being grouped together.

DISCUSSION OF 1952 RESULTS

Although control of alfalfa insects was not very effective on the small plots used in 1952 the following trends were evident:

1. Dieldrin showed the greatest control of the plant bugs *Lygus* spp. and *Adelphocoris* spp.

2. Dieldrin and malathion were most effective on aphids, although aphids crush so easily that counts obtained by sweeping are not reliable.

3. Methoxychlor and dieldrin were most effective on spittle-bug adults.

4. Methoxychlor gave greatest protection from leafhoppers, with DDT being second in effectiveness. Chlordane, aldrin and dieldrin gave apparently no leafhopper control. Malathion indicated initial control of leafhoppers, but populations built up rapidly in the situation peculiar to these plots.

Because the plots were located at one end of a 20-acre field of alfalfa it is felt that reinfestation was more rapid and control less decisive than would have been the case had the plots been more isolated or if the tests had been carried out on a field scale. The correct amount of insecticide per acre, as well as the concentration of spray, and the relative merits of sprays and dusts are questions not fully answered by the 1952 work. It was felt that spray in the amounts and with the pressure used did not wet the alfalfa sufficiently to effect good insect control regardless of reinfestation.

LARGE PLOT STUDIES IN 1953

The 20-acre field of Ranger alfalfa that had been used for plot work in 1952 was used again in 1953. The alfalfa was cut for hay the last week of June and the field then marked off into 13 plots. Duplicate randomized plots were dusted with a Niagara field duster on July 14, using the following materials:

Methoxychlor—E-Z Flow Marlate 5 percent dust at 40 pounds to the acre.

Malathion—American Cyanamid Co. 4 percent dust at 40 pounds to the acre.

CPR—E-Z Flow No. 100 at 40 pounds to the acre containing actual pyrethrins 0.10 percent, Piperonyl cyclonene technical 0.21 percent, rotenone 1.00 percent, other cube resins 1.60 percent.

BHC—E-Z Flow at 40 pounds to the acre containing Gamma isomer 1 percent, other isomers 5.30 percent.

Methoxychlor 5 percent and Malathion 4 percent dust, at 25 pounds of each to the acre.

The same sweeping and sampling methods were used as in 1952. Plots ran the full width of the field, and 10 sweeps were taken on each end of every plot. Because the plots were duplicated, each count in the records represents 40 sweeps. Sweeps were taken, beginning at 1:30, on the afternoons of July 17 and 24 and August 6, with results for the major insects shown in Table 3.

TABLE 3—Results of treatments as indicated by insect counts, 1953

LEAFHOPPERS

	July 17	July 24	August 6	Total swept
Methoxychlor	17	179	307	503
Malathion	3	145	613	761
C P R	37	123	651	811
B H C	66	144	389	599
Methoxychlor and Malathion	7	87	151	245
Check	215	453	744	1412

SPITTLEBUG ADULTS

	July 17	July 24	August 6	Total swept
Methoxychlor	135	410	236	781
Malathion	67	269	260	596
C P R	201	254	190	645
B H C	152	156	239	547
Methoxychlor and Malathion	42	155	200	397
Check	598	566	260	1424

PLANT BUGS (*Lygus* spp. and *Adelphocoris* spp.)

	July 17	July 24	August 6	Total swept
Methoxychlor	9	30	123	162
Malathion	7	19	99	125
C P R	40	41	99	180
B H C	6	12	34	52
Methoxychlor and Malathion	6	24	108	138
Check	46	45	245	336

DISCUSSION OF 1953 RESULTS

The effectiveness and relative merits of insecticides in controlling alfalfa insects were indicated much more clearly in 1953 than in 1952. In 1953 the plots were much larger, dusts were used instead of sprays and the amount of actual toxicant per acre was somewhat higher. The larger plots are considered desirable for other than preliminary tests. Because of favorable weather the dusts remained suspended and circulated throughout the plants for several minutes so as to contact insects on both sides of the leaves.

Field observations indicated:

1. Characteristic yellowing of the leaves was evident on the untreated plots and in other fields in the area.

2. Treated plots, where leafhoppers were controlled, stayed green and showed more profuse bloom than untreated plots.

3. These conditions were sufficiently evident that the boundaries of one untreated plot, located between a plot treated with malathion and methoxychlor and one treated with BHC, could be clearly discerned, even in a color photograph.

Inspection of Table 3 brings out the following points:

1. Leafhoppers were controlled best with a mixture of methoxychlor and malathion. Malathion alone gave good initial kill, but a high population had developed 23 days after treatment. Counts on the untreated plots indicate that the leafhopper populations built up rapidly during the period in which sweeps were made (July 16-August 6).

2. Spittlebug adults were also controlled best with a mixture of methoxychlor and malathion, with BHC being second in effectiveness. Adult spittlebug populations decreased on untreated plots as the alfalfa plants matured.

3. BHC gave best control of the plant bugs *Lygus* spp. and *Adelphocoris* spp. Populations of plant bugs increased during the period of the tests, bearing out the fact that these insects become plentiful in time to suck plant juices from the flower buds.

4. Malathion seemed to give protection against grasshoppers, but grasshopper counts are omitted from the tables because populations were too low and distribution in the field too erratic to give any definite indications of control.

SUGGESTIONS FOR CONTROL OF HARMFUL ALFALFA INSECTS

1. Spraying or dusting is expensive, so it is desirable:

a) To know whether there are enough harmful insects in the field to warrant spraying. More than one spittle mass per plant, observed in late April or early May, indicates that likely it would be profitable to treat the field for spittlebugs. Leafhopper damage cannot be easily forecast, but if leafhoppers are found to be widely distributed throughout the field before the first hay is cut, control will likely be warranted for the second cutting.

b) To apply the insecticides at the right time to kill the insects.

c) To control as many harmful insects as possible with the minimum number of insecticide applications.

2. Control of harmful insects in alfalfa varies, depending upon whether the crop is grown for seed or hay. The most serious pests affecting the hay in Michigan seem to be spittlebug nymphs on the first cutting and leafhoppers on the second. If alfalfa is grown for seed, spittlebug nymphs, leafhoppers and plant bugs can be serious pests.

3. Spittlebug nymphs were not considered in these tests, but their control has been well worked out. These nymphs cause damage in the spring. Because the eggs are laid in the stubble in the fall it is possible to eliminate these insects from a field by spring spraying. As a result, the yield of hay may be greatly increased. If spittlebugs are numerous on a first-cutting seed crop, control is desirable in order to maintain the vitality of the plants. The following insecticides have been used effectively for control of spittlebug nymphs; methoxychlor, toxaphene, lindane, BHC and heptachlor, applied in Michigan during the first 10 days of May. Because these materials are poisonous they should be applied far enough in advance of cutting so that the hay will not contain toxic residue. Information on the required safe period is available for any material approved for use on forage crops. Take time to read the labels on insecticide containers for information with regard to their proper use.

4. Leafhoppers seemed to be the most harmful insects affecting alfalfa during the period of the observations here recorded. Diseases and drought can cause alfalfa leaves to turn yellow, but in the tests reported the obvious primary cause of the yellowing was insects; yellowing was definitely checked in plots in which insects were controlled. Leafhoppers seem to be the chief culprit in causing the yellowing, and the damage results in a great loss in quality and quantity of hay. Leafhopper control may be warranted in alfalfa for seed production also, inasmuch as the plants become stunted and bloom is reduced. Loss of bloom means that the plants are less attractive and less valuable to bees, resulting in a reduced seed yield.

Leafhopper populations in Michigan do not build up until after the middle of June so first-cutting hay is not greatly affected by them. Delayed cutting of first-growth alfalfa will destroy many leafhopper eggs and thereby give some cultural control of these insects for the second growth. The best time to spray or dust for leafhoppers is

when the second-cutting growth is about 4 inches high. In the tests reported a mixture of methoxychlor and malathion in dust form gave the best control. About 1 pound per acre of each material is effective. In addition to being effective, methoxychlor and malathion are among the safest insecticides to use in respect to preventing harm to farm animals. It is very important to use on a forage crop materials which do not persist on the crop as a residue that would be harmful to animals or to human beings.

Leafhoppers when present on second-cutting alfalfa intended to be left for seed should also be controlled as suggested above. If first-crop alfalfa is used for seed, leafhoppers will not need to be controlled until it is time to spray or dust for plant bug control during the bud stage.

5. Spittlebug adult populations were also reduced with methoxychlor and malathion. Although no specific damage can be attributed to spittlebug adults at the present time, they feed on alfalfa in enormous numbers. When their control is incidental to the control of another insect it should be desirable.

6. Plant bugs, which include the lygus bugs, the alfalfa plant bug and the rapid plant bug are chiefly harmful to alfalfa grown for seed. They suck juices from the buds, causing the flowers to wither and die. They can be a limiting factor in seed production and usually warrant control in Michigan. Because timing is important in effecting control, insecticides should be applied when alfalfa is in the bud stage and in the very early bloom stage. DDT is widely used for that purpose, but dieldrin gave more effective control than DDT in the 1952 tests. If the forage material left after the seed is threshed is to be fed to livestock, malathion or parathion should be used because these chemicals have a short period of residual toxicity.

7. While alfalfa is in bloom various types of bees visit the bloom and carry pollen from one flower to another. Pollination by these insects is necessary for seed production; therefore, no insecticides should be applied while the plants are in bloom, or many beneficial insects will be destroyed and, as a result, seed yield reduced. If an outbreak of grasshoppers or armyworms makes full-bloom spraying necessary in order to save the crop, toxaphene should be applied in the evening after the bees have left the field. Of the insecticides mentioned in this article, toxaphene has been proven to be the least harmful to bees. The straw should not be fed, however, if toxaphene is used during the bloom period.

THE OCCURRENCE OF ANTIBACTERIAL SUBSTANCES IN SEED PLANTS WITH SPECIAL REFERENCE TO *MYCOBACTERIUM TUBERCULOSIS*[1]

(Fourth Report)

By ARDETH FRISBEY, R. Y. GOTTSHALL, J. C. JENNINGS, and E. H. LUCAS

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THE present report follows the outline of earlier publications on the same subject.[2,3,4] This paper covers a testing period extending over the years 1952 and 1953. Being a screening procedure, the work reported had to deal with as many species as possible. When a screening program is started its pursuit must be planned for an extended period; otherwise, the purpose of the initial plan would be defeated. It is the opinion of the authors that limiting the scope of the investigation constitutes a decisive weakness of any program of screening.

Youmans *et al.*,[5] in a recent publication of the results of a screening program conducted with chemicals, made the very pertinent remark that in a screening program there should be no basis for selection except availability. They state that the purpose of a screening program is likely to be defeated when an attempt is made to find a rationale for the selection of substances. This can be also applied to a program such as the one here described; in fact, since one is dealing in this instance not with chemical compounds but with crude drugs which may or may not be carriers of effective substances, random selection is the only initial approach possible. In the course of the investigation, however, a rationale may come into focus which can

[1]This investigation was supported in part by research grant E-227(C) from the National Institute of Health, of the National Institutes of Health, Public Health Service.

[2]Gottshall, R. Y., E. H. Lucas, Ardeth Lickfeldt, and J. M. Roberts (1949). The occurrence of antibacterial substances active against *M. tuberculosis* in seed plants. Jour. Clin. Investig. 28: 920-923.

[3]Lucas, E. H., Ardeth Lickfeldt, R. Y. Gottshall, and J. C. Jennings (1951). The occurrence of antibacterial substances in seed plants with special reference to *Mycobacterium tuberculosis*. Bul. Torrey Bot. Club 78: 310-321.

[4]Frisbey, Ardeth, J. M. Roberts, J. C. Jennings, R. Y. Gottshall, and E. H. Lucas (1953). The occurrence of antibacterial substances in seed plants with special reference to *Mycobacterium tuberculosis* (Third report). Mich. Agr. Expt. Sta. Quart. Bul. 35: 392-404.

[5]Youmans, G. P., L. Doub, and Anne S. Youmans (1953). The bacteriostatic activity of 3500 organic compounds for *Mycobacterium tuberculosis* var. *hominis*. Review No. 4, Chemical Biological Coordination Center, National Research Council, Washington, D. C.

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be used as a practical guide, such as the occurrence of inhibitory properties against the test organism in plants of botanical relationship. Quite frequently species of the same genus exhibit similar properties in the *in vitro* test. Occasionally, this similarity extends throughout families. This may not be due to the presence of identical substances but is more likely to be due to related compounds, a possibility which enhances the importance of following such a lead. Minor structural differences in compounds may make a difference in the magnitude of biological activity; quite often a minute structural change may spell the difference between antibacterial activity and lack of it. These considerations may tend to narrow down a screening procedure to a more vigorous pursuit of the study of certain groups of plants. In this case one is leaving, of course, the field of screening in order to undertake a special investigation.

In their work during the past 6 years, the authors have attempted to maintain the course of screening in spite of special investigations which developed occasionally and were conducted as separate units. This was believed to be the most logical approach.

In the most recent phase of this work, which is described in the present paper, it was possible to gain access to a very valuable source of plant materials through the courtesy of Dr. J. J. Willaman of the Eastern Regional Research Laboratory, U. S. Department of Agriculture. The authors are happy to acknowledge this important contribution which has enabled them to extend their screening into families, species and genera, which otherwise would have been beyond their reach.

METHODS

Since the earlier communications furnished extensive descriptions of the techniques and procedures applied,[6] it will suffice to say that essentially the same were used in the continuation of the work.

More emphasis has been placed in recent years on *in vitro* tests in the presence of blood. Although these tests were conducted routinely with preparations that had been found to be of considerable activity they were not made with the majority of the plant materials examined. It is generally agreed that substances of chemotherapeutic value must show their inhibitory action in the presence of whole blood or serum; complete inactivation by blood usually eliminates a compound from consideration for clinical application. It cannot be ruled out, however,

[6]See footnotes 2, 3, 4.

that blood constituents may have a synergistic effect and may thus enhance the inhibitory action. This would encourage routine testing on blood media. It is presumed, however, that crude drugs, such as are being subjected to the tests here described, contain too many constituents besides the active principles to make an immediate evaluation of blood interference particularly useful. The procedure followed at present, therefore, requires a preliminary screening on the regular medium, followed by partial purification if activity seems to warrant it. The partially purified preparations are then subjected to repeated *in vitro* tests which include examinations on a medium containing 10 percent whole sheep blood.

RESULTS AND DISCUSSION

The system of classification, which was followed in the paper by Youmans *et al.*,[7] and described there, was also utilized in the present sequel. The plant extracts obtained from the Eastern Regional Research Laboratory, however, were designated according to the list made available to the authors. This classification is obviously based on numerous sources since many of the plants included are specific to certain areas and are, therefore, listed in the literature dealing with the flora of distinct regions. An asterisk (*) identifies any of these species in the list of materials tested. Since the Eastern Regional Research Laboratory originally used these materials for other purposes and subsequently made aliquots available, only ethanol extracts were examined.

During the two-year period covered by this report 284 species were tested. This number includes species that had been tested before, only if plant parts other than those examined in previous tests were used. These species belong to 82 different families, of which 20 are appearing for the first time.

Extracts of all parts tested of the following species gave negative results with all organisms used:

*Abbevillea fenzliana**
*Abelia grandiflora**
Achillea ptarmica
*Achras zapota**
*Acorus calamus**
*Adenanthera pavonina**
*Agapanthus hollandii**
*Agapanthus inapertus**
*Agapanthus pendulinus**
*Agave franceschiana**
Agropyron repens
Agrostis nigra
*Albuca nelsoni**
*Albuca setosa**
*Aloe brevifolia**
*Aloe davyana**

[7]See footnote 5.

*Aloe sublaevis**
Amsonia tabernaemontana
*Ananas comosus, Cayenne**
Anchusa azurea
*Aralia chinensis**
Aralia racemosa
*Ardisia wallichi**
*Argemone alba**
*Arisaema triphyllum**
Asclepias incarnata
*Asparagus officinalis**
*Astelia neocaledonica**
*Beaucarnea inermis**
*Berrya quinqueloculari**
*Blighia sapida**
*Boenninghausenia albiflora**
*Bowiea volubilis**
*Brassaia actinophylla**
*Brodiaea uniflora**
*Brosimum alicastrum**
*Buddleia alternifolia**
*Bursera bipinnata**
*Bursera fagaroides**
*Campsis radicans**
*Carissa arduina**
*Carissa grandiflora**
*Carpinus cordata**
*Carpinus tschonoski**
*Carpodiptera ameliae**
Cassia marilandica
*Catalpa hybrida, Japanese**
Cattleya sp.
Chenopodium bonus-henricus
*Chionanthus retusus**
*Chorisia insignis**
*Chorisia speciosa**
*Chrysalidocarpus madagascariensis**
Chrysanthemum majus tanacetoides
*Cistus crispus**
*Cistus monspeliensis**
Clematis recta
*Clematis virginiana**
*Clethra alnifolia**
*Cnidoscolus texanus**
Coelogyne sp.
*Cordia obliqua**
Cuphea platycentra
Cynanchum vincetoxicum
Dactylis glomerata
*Dasylirion cf. durangense**
*Dasylirion cf. simplex**
*Dasylirion wheeleri**
*Dianella tasmanica**
*Dion edule**
*Dioscorea glauca**
*Dioscorea macrostachya**
*Drimia sp.**
*Duranta repens**
Echinacea purpurea
*Eucalyptus obtusiflora**
*Eugenia coronata**
Feijoa sellowiana
*Ficus auriculata**
*Ficus fulva**
*Forchammeria watsoni**
*Franklinia alatamaha**
*Fraxinus chinensis**
*Fraxinus oregona**
Gardenia jasminoides
Hemigraphis colorata
Hibiscus syriacus, Blue
*Hydrangea petiolaris**
*Hydrangea radiata**
Hypericum kalmianum
Isoloma bogotense
*Ixora coccinea**
*Koelreuteria formosana**
*Lagerstroemia speciosa**
Lantana trifolia
Lavandula officinalis
*Ligustrum japonicum**
*Liriope spicata**
Lolium perenne
Macadamia ternifolia
Mahonia aquifolium
*Melia azedarach**
Morinda citrifolia
*Myrciaria cauliflora**
Myrica gale
*Myrica rubra**
*Nauclea esculenta**
*Neillia longiracemosa**
*Nolina greenei**
*Nolina microcarpa**
*Nolina palmeri**
*Nolina parryi**
Origanum vulgare
*Oxytria crocea**
*Periploca graeca**
*Philadelphus henryi**
*Phoenix tomentosa**
*Phoradendron pachycereus**
*Phormium tenax**
*Photinia parvifolia**

Physalis pubescens
Poa annua
Poa pratensis
*Polygonum affinis**
Polygonum auberti
*Prunus serrulata**
*Prunus subhirtella**
*Pyrus calleryana**
Pyrus communis
*Quillaja saponaria**
*Radermachera fenicis**
*Rhodotypos scandens**
*Ribes manshuricum**
*Rohdea japonica**
*Ruscus aculeatus**
Scindapsus aureus
*Serenoa repens**
*Simmondsia chinensis**
*Smilax herbacea**
*Spondias cytherea**
Stachys officinalis
*Stenolobium stans**
*Stephania cepharantha**
*Stranvaesia davidiana**
*Strophanthus hispidus**
Symphytum asperum
*Syringa oblata**
*Syzygium jambos**
*Tilia dasystyla**
*Veratrum viride**
Verbascum blattaria
*Viburnum cassinoides**
*Vigna sinensis**
*Yucca faxoniana**
*Yucca filamentosa**
*Yucca gloriosa**
*Yucca recurvifolia**
*Yucca schidigera**
*Yucca torreyi**
*Yucca whipplei**
*Zanthoxylum simulans**
*Zizyphus mauritiana**

Table 1 lists all species in which one or more parts were found to be antibacterial against any of the test organisms. Arrangement of the table and abbreviations used conform to those in the three preceding publications.

TABLE 1—Activity of plant extracts against Mycobacterium tuberculosis and other microorganisms

Plant name	Plant part†	Result‡			
		M. tuberculosis	*Micrococcus pyogenes*, var. *aureus*	*Salmonella typhimurium*	*Escherichia coli*
Acanthaceae					
Strobilanthes isophyllus....	L	–	B+	–	–
	St	B+	–	–	–
	R	–	B+	–	–
Aceraceae					
Acer platanoides.....	L	C+++	B+,C+	–	–
	Fl	A+	B+	–	–
Anacardiaceae					
Rhus aromatica.....	L	B+	A+	–	–
	St and pist. catkins	–	A+,B+	–	–
	Fr	–	–	–	–

†Plant parts are abbreviated as follows: bud, Bd; bulb, Bu; entire plant, E; flower, Fl; fruit, Fr; leaf, L; root, R; seed, Se; stem, St.

‡Activity is indicated by + (active in dilutions below 1:20), ++ (active in dilutions between 1:20 and 1:80), or +++ (active in dilutions above 1:80). A, B, or C preceding these signs indicates cold water, boiling water, or ethanol respectively. Lack of activity is signified by –.

TABLE 1—Continued

Plant name	Plant part†	Result‡			
		M. tuberculosis	*Micrococcus pyogenes*, var. *aureus*	*Salmonella typhimurium*	*Escherichia coli*
Apocynaceae					
Apocynum androsaemifolium	L	A+,B+	A+,B+,C+	B+	–
	St	–	B+,C+	–	–
	Fr	B+	B+	–	–
	R	–	–	–	–
Apocynum cannabinum....	L	–	–	–	–
	St	–	–	–	–
	R	–	B+	–	–
	Fl	B+	–	–	–
Araceae					
Nephthytis afzeli.....	L	A+	A+	A+	A+
	St	–	–	–	–
	R	–	–	–	–
Asclepiadaceae					
Asclepias tuberosa.....	L	–	–	–	–
	St	A+	–	–	–
	R	–	–	–	–
	Fl	–	–	–	–
Betulaceae					
Alnus glutinosa denticulata.	L	B+	B+	–	–
*Betula davurica**.....	L	C+++	–	–	–
Bignoniaceae					
*Doxantha unguis-cati**....	L	–	C+	–	–
Caprifoliaceae					
*Dipelta floribunda**.....	L	C+++	–	–	–
Kolkwitzia amabilis.....	L	–	–	–	–
	St	–	–	–	–
	Fl and Se	–	B+	–	–
Sambucus pubens.....	L	A+	–	–	–
	St	–	–	–	–
Caricaceae					
Carica papaya.....	R	–	A+	–	–
Celastraceae					
Euonymus europaeus.....	Se	C+++	–	–	–
Compositae					
Anthemis nobilis.....	Fl	–	C+	–	–
Aster chilensis.....	L	–	–	–	–
	St	–	–	–	–
	R	–	–	–	–
	Fl	A+	–	–	–
Chrysanthemum frutescens.	L	–	–	–	–
	St	–	–	–	–
	R	A+,B+,C+++	–	–	–
	Fl	–	–	–	–
Chrysanthemum morifolium	L	–	–	–	–
	St	–	–	–	–
	R	–	C+	–	–
Eupatorium rugosum.....	L, St, Se	–	B+	–	–
Gnaphalium decurrens.....	L	B+,C+++	A+,B+,C+	A+	–
	St	–	B+,C+	–	–
	R	B+	–	–	–
	Fl	B+	B+,C+++	–	–

*See page 479.

†Plant parts are abbreviated as follows: bud, Bd; bulb, Bu; entire plant, E; flower, Fl; fruit, Fr; leaf, L; root, R; seed, Se; stem, St.

‡Activity is indicated by + (active in dilutions below 1:20), ++ (active in dilutions between 1:20 and 1:80), or +++ (active in dilutions above 1:80). A, B, or C preceding these signs indicates cold water, boiling water, or ethanol respectively. Lack of activity is signified by –.

TABLE 1—Continued

Plant name	Plant part†	Result‡			
		M. tuberculosis	*Micrococcus pyogenes*, var. *aureus*	*Salmonella typhimurium*	*Escherichia coli*
Compositae: *Continued*					
Lactuca serriola	Fl	−	A+	−	−
Liatris aspera	L	−	B+	−	−
	St	−	−	−	−
	R	−	−	−	
	Fl	A+,B+	A+,C+	−	−
Matricaria chamomilla	Fl	−	−	C+	−
Tithonia rotundifolia	L and St	−	A+	A+	A+
	Fl	−	−	−	−
Cruciferae					
Thlaspi arvense	L	A+	−	−	−
	St	−	−	−	−
	R	−	−	−	−
	Fl and Se	A+	−	−	−
Cupressaseae					
Chamaecyparis pisifera	L	B+,C+++	B+,C+++	−	−
	St	C+++	B+,C+++	−	−
Chamaecyparis pisifera, Thread	L	B+,C+++	B+,C+++	−	−
	St	B+,C+++	B+,C+++	−	−
Elaeagnaceae					
*Hippophae rhamnoides**	L	C+++	−	−	−
Ericaceae					
Kalmia latifolia	L	A+,B+,C+++	A+	−	−
	St	−	−	−	−
	R	−	−	−	−
Rhododendron maximum	L	−	A+,B+	B+	B+
	St	−	B+	−	−
	FlBd	−	B+	C+	−
	Se	B+	B++	B+	B+
Euphorbiaceae					
Ricinus communis	L	A+,B+	−	−	−
	Fr	−	−	−	−
Fagaceae					
Quercus borealis	L	B+	B+	−	−
	St	−	B+	−	−
Quercus coccinea	L	−	B+	−	−
	St	B+	B+	−	−
Fouquieriaceae					
*Fouquieria peninsularis**	Bark	C+++	−	−	−
Geraniaceae					
Pelargonium zonale	L and St	B+	−	−	−
	R	−	−	−	−
Gramineae					
Agrostis alba	L,St,Fl	−	−	−	−
	R	B+	−	−	−
Avena sativa	L and St	−	−	−	−
	R	B+	−	−	−
	Se	−	−	−	
Bromus inermis	L and St	A+	B+	−	−
	R	A+	−	−	−
	Fl	A+	−	−	−

*See page 479.

†Plant parts are abbreviated as follows: bud, Bd; bulb, Bu; entire plant, E; flower, Fl; fruit, Fr; leaf, L; root, R; seed, Se; stem, St.

‡Activity is indicated by + (active in dilutions below 1:20), ++ (active in dilutions between 1:20 and 1:80), or +++ (active in dilutions above 1:80). A, B, or C preceding these signs indicates cold water, boiling water, or ethanol respectively. Lack of activity is signified by −.

TABLE 1—Continued

Plant name	Plant part†	Result‡			
		M. tuberculosis	*Micrococcus pyogenes*, var. *aureus*	*Salmonella typhimurium*	*Escherichia coli*
Gramineae: *Continued*					
Phalaris arundinacea.....	L	B+	−	−	−
	St	−	−	−	−
	R	−	−	−	−
	Fl	−	−	−	−
Phleum pratense.....	L	−	−	−	−
	St	−	−	−	−
	R	B+	−	−	−
	Fl	B+	−	−	−
Hypericaceae					
Hypericum moserianum....	Fl	−	C+++	−	−
Hypericum polyphyllum...	Fl	−	C+	C+	−
Labiatae					
Ballota nigra.....	L,St,Fl	B+	−	−	−
Salvia farinacea.....	L	−	−	−	−
	St	−	−	−	−
	Fl	B+	−	−	−
Lauraceae					
Persea americana.....	L	−	−	−	−
	St	−	B+	−	−
	R	−	A+,B+	−	−
Leguminosae					
Baptisia australis.....	L and St	B+	B+	−	−
	Se and Pod	−	−	B+	−
Coronilla varia.....	L and St	B+	−	−	−
Genista tinctoria.....	L	B++,C+++	A+	−	−
	St	A+,B++	−	−	−
	Fl	B++,C+++	−	−	−
*Glycyrrhiza glabra**.....	E	C+++	−	−	−
Myroxylon balsamum.....	Exudate	C+++	−	−	−
Myroxylon pereirae.....	Exudate	C+++	−	−	−
Trifolium pratense.....	L and St	B+	−	−	−
	R	B++	−	−	−
	Fl	B+	−	−	−
Liliaceae					
*Aletris farinosa**.....	E	C+++	C+	−	−
*Aloe salmdyckiana**.....	L	C+++	−	−	−
*Dasylirion berlandieri**....	L,FlBd	−	C+	−	−
*Eucomis comosa**.....	E	−	C+	C+	−
Hosta japonica.....	Se and Capsule	−	−	C+	−
Trillium grandiflorum.....	L	B+	−	−	−
	St	−	−	−	−
	Fl	−	−	−	−
Veltheimia glauca.....	L	−	−	−	−
	R and Bu	B+	−	−	−
*Veratrum fimbriatum**.....	R	−	C+	C+	C+
*Yucca angustissima**.....	L	−	C+	C+	C+
*Yucca baccata**.....	L	C+++	−	−	−
Lythraceae					
*Lagerstroemia indica**.....	L	−	C+	−	−

*See page 479.

†Plant parts are abbreviated as follows: bud, Bd; bulb, Bu; entire plant, E; flower, Fl; fruit, Fr; leaf, L; root, R; seed, Se; stem, St.

‡Activity is indicated by + (active in dilutions below 1:20), ++ (active in dilutions between 1:20 and 1:80), or +++ (active in dilutions above 1:80). A, B, or C preceding these signs indicates cold water, boiling water, or ethanol respectively. Lack of activity is signified by −.

TABLE 1—Continued

Plant name	Plant part†	Result‡			
		M. tuberculosis	*Micrococcus pyogenes*, var. *aureus*	*Salmonella typhimurium*	*Escherichia coli*
Malvaceae					
Hibiscus syriacus, Pink	L	−	−	−	−
	St	−	−	−	−
	FlBd	B+	−	−	−
	Fl	−	−	−	−
Martyniaceae					
Proboscidea jussieui	L	B+	B+,C++	−	−
	Fr	−	−	−	−
Meliaceae					
*Cipadessa baccifera**	L,Fl,Fr	−	C+	−	−
Moraceae					
Cannabis sativa	L,St,Fl	A+,C+++	C+++	−	−
	R	−	−	−	−
*Cecropia guarumo**	E	C+++	−	−	−
*Ficus mysorensis subrepanda**	L	−	C+	−	−
Myrtaceae					
*Callistemon linearis**	Fr	C+++	C+	C+	−
*Eucalyptus alba**	L and Fr	C+++	−	−	−
*Melaleuca leucadendron**	L,Fl,Fr	C+++	−	−	−
Myrtus communis	R	−	B+	−	−
*Psidium molle**	L	C+++	−	−	−
Nyctaginaceae					
Mirabilis nyctaginea	L	−	−	−	−
	St	B+	−	−	−
	R	−	−	−	−
	FlBd	B+	−	−	−
Nyssaceae					
*Camptotheca acuminata**	L	C+++	−	−	−
Oleaceae					
Syringa vulgaris	L and St	A+,B+	A+	A+	A+
Onagraceae					
Epilobium coloratum	L	C+++	A+,C+	C+	−
	St	−	A+,B+	−	−
	R	−	B+	−	−
	SePod	B+,C+++	A+,C+	−	−
Oenothera biennis	L	−	A+	−	−
	St	B+	A+	−	−
	R	−	−	−	−
	Fl	C+++	B+	−	−
	SePod	C+++	A+,B+	A+	−
Orchidaceae					
Epidendrum sp.	St	−	−	−	−
	R	C+++	C+	−	−
Pinaceae					
Larix europaea	Se	−	C+	C+	−
Picea abies	Se	−	C+	C+	−
Pinus echinata	Fr	−	C++	−	−

*See page 479.

†Plant parts are abbreviated as follows: bud, Bd; bulb, Bu; entire plant, E; flower, Fl; fruit, Fr; leaf, L; root, R; seed, Se; stem, St.

‡Activity is indicated by + (active in dilutions below 1:20), ++ (active in dilutions between 1:20 and 1:80), or +++ (active in dilutions above 1:80). A, B, or C preceding these signs indicates cold water, boiling water, or ethanol respectively. Lack of activity is signified by −.

TABLE 1—Continued

Plant name	Plant part†	Result‡			
		M. tuberculosis	*Micrococcus pyogenes*, var. *aureus*	*Salmonella typhimurium*	*Escherichia coli*
Pinaceae: *Continued*					
Pinus mugo	L	−	−	−	−
	St	C+++	C+++	−	−
Pinus nigra	Fr	−	C+	−	−
Pinus resinosa	Fr	−	C+++	−	−
Polygonaceae					
Polygonum hydropiperoides	L,St,Fl	−	B+	−	−
	R	−	B+	−	−
Polygonum lapathifolium	L	B+	B+,C+	−	−
	St	−	B+	−	−
	R	−	B+	−	−
	Fl	B+	B+	−	−
Polygonum persicaria	St	−	−	−	−
	R	−	−	−	−
	Fl	B+	B+	−	−
Polygonum punctatum	L,St,Fl	−	B+	−	−
	R	−	B+	−	−
Primulaceae					
Primula obconica	R	B+	−	−	−
	Fl	−	A+,B+	−	−
Rhamnaceae					
Ceanothus americanus	L	−	B+	−	−
	St	−	−	−	−
Rhamnus cathartica	L	A+,B+	B+	−	−
	St	B+	−	−	−
	Fr	−	B+	−	−
*Rhamnus utilis**	Fr	−	C+	−	−
Rosaceae					
*Adenostoma fasciculatum**	L	C+++	C+	−	−
Prunus cerasifera divaricata, Pissard	L and St	A+,B+,C+++	A+,B+	A+	A+
	Fl	A+	−	−	−
Prunus cerasus	L and St	B+	−	−	−
Prunus domestica	R	B+	B+,C+	−	−
Sorbus americana	L and St	−	−	−	−
	Fr	A+	−	−	−
Spiraea latifolia	L	−	C+	−	−
	St and Fl	−	B+	−	−
	R	−	B+,C+	−	−
Spiraea thunbergi	L	B+	B+,C+	B+,C+	B+
	St	−	C+	−	−
Waldsteinia geoides	L	B+	B+	−	−
Rutaceae					
*Evodia hupehensis**	Fr	C+++	−	−	−
*Murraya paniculata**	L and Fl	C+++	−	−	−
Phellodendron amurense	St	−	−	−	−
	Fr	B+	C+	−	−
Saxifragaceae					
Bergenia crassifolia	L	A+,B+	A+,B+	−	−
Heuchera americana	L	B+	A+	−	−
Ribes hirtellum	Fr	A+,B+	−	−	−
Ribes sativum, Red	Fr	−	B+,C+	−	−
Ribes sativum, White	Fr	B+	B+	−	−

*See page 479.

†Plant parts are abbreviated as follows: bud, Bd; bulb, Bu; entire plant, E; flower, Fl; fruit, Fr; leaf, L; root, R; seed, Se; stem, St.

‡Activity is indicated by + (active in dilutions below 1:20), ++ (active in dilutions between 1:20 and 1:80), or +++ (active in dilutions above 1:80). A, B, or C preceding these signs indicates cold water, boiling water, or ethanol respectively. Lack of activity is signified by −.

TABLE 1—Concluded

Plant name	Plant part†	Result‡			
		M. tuberculosis	*Micrococcus pyogenes*, var. *aureus*	*Salmonella typhimurium*	*Escherichia coli*
Scrophulariaceae					
Calceolaria herbeohybrida..	L	B+	−	−	−
	St	−	B+	−	−
	R	B+	−	−	−
*Paulownia fortunei**.....	L	−	C+	−	−
Verbascum thapsus.....	L	−	−	−	−
	St	C+++	−	−	−
	Fl	−	B+	−	−
Solanaceae					
Capsicum frutescens.....	L	A+	−	−	−
	St	−	−	−	−
	R	−	−	−	−
	Fr	−	−	−	−
Schizanthus gracilis.....	L	−	−	−	−
	St	−	−	−	−
	R	−	−	−	−
	Fl	A+,B+	−	−	−
Solanum carolinense.....	L	B+	−	−	−
	St	−	−	−	−
	Fl	−	−	−	−
Taxodiaceae					
Cryptomeria japonica.....	L and St	C+++	B+	−	−
Metasequoia glystostroboides	L	C+++	−	−	−
	St	−	−	−	−
Ulmaceae					
*Celtis caucasica**	L and Fr	−	C+	−	−
Umbelliferae					
*Cryptotaenia canadensis**..	St and R	−	C++	−	−
Verbenaceae					
Callicarpa dichotoma.....	L and St	B+	−	−	−
Caryopteris incana.....	L and St	−	B+,C+	−	−
Violaceae					
Viola tricolor.....	L	A+	A+	−	−
	St	−	−	−	−
	R	−	−	−	−
	Fl	−	−	−	−
	Se	−	−	−	−
Xyridaceae					
*Xyris flexuosa**.....	R	−	C+	−	C+

*See page 479.

†Plant parts are abbreviated as follows: bud, Bd; bulb, Bu; entire plant, E; flower, Fl; fruit, Fr; leaf, L; root, R; seed, Se; stem, St.

‡Activity is indicated by + (active in dilutions below 1:20), ++ (active in dilutions between 1:20 and 1:80), or +++ (active in dilutions above 1:80). A, B, or C preceding these signs indicates cold water, boiling water, or ethanol respectively. Lack of activity is signified by −.

SUMMARY

1. The results of the fourth period of screening extracts of seed plants for presence of substances antagonistic to *M. tuberculosis* are presented.

2. Species belonging to 82 families were tested during the years 1952 and 1953. Extracts of plants belonging to 52 families exhibited antibacterial activity. The total number of species examined during the two-year period is 284.

3. One hundred and twenty-three species contained principles that inhibited *in vitro* growth of *M. tuberculosis*, 44 of which had specific activity. Antibacterial activity against *Micrococcus pyogenes*, var. *aureus*, *Salmonella typhimurium* and *Escherichia coli* was also recorded.

JOURNAL ARTICLE ABSTRACTS

The Influence of Copper Compounds on the Yield, Growth Pattern and Composition of Spring Wheat and Corn Grown on Organic Soil

BROWN, JOHN C., AND P. M. HARMER

Soil Sci. Soc. Amer. Proc. 16: 284-291. 1951 (Journal Article 1187 from the Michigan Agricultural Experiment Station)

This greenhouse study was made to investigate the role which copper might have in the growth of wheat and corn. An organic soil (pH 5.7) containing 0.0011 percent total copper was fertilized with several copper compounds and silicic acid. The results reported describe plant symptoms and show the effect of copper and silicic acid on the growth, the reducing sugar, and the mineral content of the plants.

The omission of copper fertilization resulted in very large concentrations of N, P, K in the plant. In the absence of copper, wheat showed inability to assimilate these elements. Furthermore, the reducing sugar content was low. A comparison of several copper materials showed that all gave marked increases in plant growth, except metallic copper, which gave slightly less growth response. The study also pointed out that copper-deficient plants had a lower percentage of chlorophyll and a higher ash content.

The Application of Electrostatic Charging to the Deposition of Insecticides and Fungicides on Plant Surfaces

BOWEN, H. D.; PETER HEBBLETHWAITE, AND W. M. CARLETON

Agr. Engin. 33: 347-350. 1952 (Journal Article 1336 from the Michigan Agricultural Experiment Station)

Conventional dusting machinery is inefficient, both in respect to percentage of dust deposited and in the distribution of the dust on the plant. The combining of electrostatic and dynamic forces results in better distribution and more efficient application. In the ionized field method of charging, the particles of dust in an air stream are passed through a charging nozzle which contains air ions of one sign only. The air ions moving very rapidly across the nozzle at right angles to the air-dust stream encounter and attach themselves to the dust particles, which results in a charge on the particles.

Field tests indicated an increased deposition on the plants, but more work is necessary on the interaction of dust particle sizes, velocities, relative humidity, and charging currents.

The Effect of Sodium Trichloroacetate Upon the Metabolism of Wheat Seedlings

REBSTOCK, T. L.; C. L. HAMNER; R. W. LUECKE, AND H. M. SELL

Plant Physiol. 28: 437-442. 1953 (Journal Article 1342 from the Michigan Agricultural Experiment Station)

The shoots of wheat plants grown in soil treated with sodium trichloroacetate contained a higher percentage of crude protein, arginine, acid-hydrolyzable

polysaccharide and reducing sugar. A decrease was observed in the percentage of non-reducing sugar, ether extract, unsaponifiable material, fatty acids and tryptophan. The roots of plants grown in treated soil showed a slight increase in the percentage of crude protein, amino acids, reducing sugar and starch, while the percentage of non-reducing sugar and ether extract did not change. Respiratory activity was greater in both the shoots and roots of plants grown in the treated soil.

Some Mineral Changes in the Skeletal and Heart Muscles of Vitamin E Deficient Lambs

BACIGALUPO, F. A., AND R. W. LUECKE

Jour. Anim. Sci. 13: 245-248. 1954 (Journal Article 1408 from the Michigan Agricultural Experiment Station)

Skeletal and heart muscles from suckling lambs fed vitamin E-deficient and E-supplemented diets have been analyzed for several inorganic elements. The results of these analyses revealed that skeletal muscles from vitamin E deficient lambs had a higher concentration of Na and Ca and a lower concentration of K than did skeletal muscles from normal control lambs. Heart muscle from vitamin E deficient lambs contained more Ca and P than those from normal control lambs.

Effect of Growth Regulating Compounds on the Development of Basal Shoots of Greenhouse Roses

ASEN, SAM, AND C. L. HAMNER

Bot. Gaz. 115: 86-89. 1953 (Journal Article 1419 from the Michigan Agricultural Experiment Station)

Several growth-regulating compounds (ethylene chlorohydrin, naphthalene acetic acid, naphthoxy acetic acid, 2, 3, 5-triiodobenzoic acid, and a mixture of all four) were tested for their effect on the development of basal shoots of greenhouse roses. These shoots are highly desirable because they rejuvenate old bushes as well as enhance flower production. The only chemical from which a significant response was received was 2, 3, 5-triiodobenzoic acid. The effect was to increase the number of basal shoots per plant and the number of plants developing basal shoots by 163 percent and 101 percent respectively. A possible mechanism of action and the relation to light intensity are discussed.

Tillage Methods Influence Crop Yields

COOK, R. L.; L. M. TURK, AND H. F. MCCOLLY

Soil Sci. Soc. Am. Proc. 17: 410-415. 1952 (Journal Article 1426 from the Michigan Agricultural Experiment Station)

Tillage experiments involving seven methods of tillage were conducted over a period of 6 years on four different soils. Conventional tillage was compared with rotary tillage and two other methods which mixed vegetation with the surface soil. The use of the subbase plow and a study of minimum tillage requirements were included. Rotary tillage and the other methods which involved machines

which mixed the vegetation with the surface soil proved to be less satisfactory than those which involved the use of the moldboard plow. Use of the subbase plow did not result in significantly greater yields than did the conventional plow. Certain minimum tillage methods showed that, after a good job of moldboard plowing, very little tillage is necessary for maximum yields of oats, sugar beets, corn, and beans. Weed control was easier after the soil had been fitted by the minimum tillage methods.

Some Effects of Photoperiodicity and Thermoperiodicity on Vegetative Growth, Flowering and Fruiting of the Tomato

LEARNER, E. N., AND S. H. WITTWER

Proc. Amer. Soc. Hort. Sci. 61: 373-380. 1953 (Journal Article 1430 from the Michigan Agricultural Experiment Station)

Tomato seedlings grown in winter and in an environment in which the normal photoperiodic exposure was extended to 16 hours by using 300 foot-candles of white fluorescent light had significantly greater heights and dry weights of foliage and roots. The time of first anthesis occurred earlier, and fruit ripening was promoted. In addition, significant yield increases of No. 1 fruit were obtained from additional lighting during seedling growth. Seedlings of Michigan State Forcing which were germinated and grown under night temperatures of 80° F. for 10 days, then 70° F. until transplanting time plus an additional light supplement of 16 hours of 300 foot-candles of white fluorescent light yielded 18 percent greater total weight of fruit and 30 percent in total weight of No. 1 fruit. Correspondingly, these same plants produced fruits for harvest 13.1 days earlier and fruit which contained 18.4 percent less green placental tissue. A significant variety interaction with night temperatures was noted in the growth and fruiting responses of Early Chatham, John Baer and Rutgers tomatoes. Optimum temperature requirements were the lowest with Early Chatham and highest with Rutgers. With John Baer and Rutgers the intensity of the fruiting response was directly related to each increase in temperature. This was not, however, true of Early Chatham which fruited equally as well at 60° as at 70° F., and produced an appreciable number and weight of fruit even at 40° and 50° F.

The Uptake of Nutrients by Leaves and Bark of Fruit Trees

TUKEY, H. B.

Rept. of the Thirteenth Internat. Hort'l Congress. (1952) 297-306. 1953 (Journal Article 1442 from the Michigan Agricultural Experiment Station)

Studies with radioactive isotopes have shown that such materials as orthophosphoric acid, potassium carbonate and urea may move readily into the aboveground parts of plants not only into the leaves but also into the branches—even in mid-winter. Phosphorus and nitrogen tend, to a limited degree, to move towards regions of greatest metabolic activity in the plant, whereas potassium is more generally distributed.

The surface area of a dormant 25-year-old apple tree was determined as 86.00 square meters. Such a tree was capable of retaining 1,364 grams of urea from a 32-percent spray. Apple leaves retained more nutrient material than

did pear, sour cherry, peach and sweet cherry leaves in the ratio of 23, 17, 6.9, 5.6 and 5.6, respectively.

Urea was hydrolized at different rates by different plants. For leaves of the apple, cherry and peach the ratio was 42, 15 and 15, respectively. For comparison, the ratio for cucumber was 425, bean 160, grape 100, tomato 83, raspberry 70, corn 65, celery 20 and potato 20. Tolerance of high concentrations of urea was in inverse relationship to the rate of hydrolysis.

Urea was hydrolized by the bark of apple, cherry and peach in the ratio of 30, 10 and 8, respectively. If leaves were present, hydrolysis was markedly increased in the apple to 130, and to 32 and 20 for the cherry and peach, respectively.

Acids and Chloramphenicol as Sanitizing Agents for Meat Contaminated with Food Poisoning Organisms

COMUTPUTRA, CHOOMPHORN, AND F. W. FABIAN

Jour. Milk and Food Technol. 16: 220-227. 1953 (Journal Article 1448 from the Michigan Agricultural Experiment Station)

A study was made to determine the difference in the amount of growth of food-poisoning organisms, a) on the surface of raw lean pork and beef taken 1 cm. beneath the surface of retail cuts, b) on the autoclaved lean pork and beef, and c) on the surface of regular retail cuts of raw lean pork and beef. The growth was least on the surface of the retail cuts of the meats, owing to antagonism offered by other bacteria and to desiccation.

The raw pork and beef were found to be good media for the growth of food-poisoning staphylococci and salmonellae. Experimental incubation of the inoculated meats at various temperature ranges showed that the organisms increased to large numbers at 15.6°-32.2° C. (60°-90° F.). The pork rind and the external fat covering the beef carcass were found to be poor media for the growth of the organisms at various temperature ranges.

A comparison of the germicidal effect of trichloracetic acid, dichloracetic acid, dehydroacetic acid (sodium salt), monochloracetic acid, acetic acid, and chloraphenicol on the food poisoning organisms showed acetic acid to be more germicidal than the other acids in 1 percent solution and, also, than 10 μg. ml. chloraphenicol. Four percent vinegar was found to be a practical and a more effective dipping solution than 1 percent acetic acid in destroying the food poisoning organisms on the pork and beef. The solution did not impart any appreciable flavor to the meats.

A method of surface plating to determine the number of staphylococci and salmonellae on a selective and a differential medium, respectively, is described.

Determination of Arsenic in Biological Materials

EVANS, R. J., AND S. L. BANDEMER

Analyt. Chem. 26: 595-598. 1954 (Journal Article 1471 from the Michigan Agricultural Experiment Station)

Homogenized liquid egg contents were mixed with saturated magnesium nitrate solution in a filter-paper-lined crucible, charred over a Meker burner,

and ashed overnight at 600° C. in a muffle furnace. Finely minced fresh tissues or ground dried materals were mixed with magnesium nitrate solution in a crucible lined with filter paper and vegetable parchment paper, evaporated to dryness on the steam bath, slowly ignited in the muffle furnace, and ashed overnight at 600° C. The ash was dissolved in dilute hydrochloric acid and the arsenic distilled from the ash as arsine, which was collected in an iodine solution. The arsenic content of the solution was determined by developing the heteropoly blue compound of arsenic and reading the color with a Beckman Model B spectrophotometer with an 840 mμ wavelength light source.

Some New Esters of 2,4-Dichlorophenoxyacetic Acid and Their Herbicidal Activity

WAGNER, C. R.; C. L. HAMNER, AND H. M. SELL

Jour. Am. Chem. Soc. 75: 4861. 1953 (Journal Article 1475 from the Michigan Agricultural Experiment Station)

Sixteen new esters of 2,4-dichlorophenoxyacetic acid have been prepared. The herbicidal activity of these compounds was evaluated by comparing the number of germinated seeds, total fresh weight and height of the treated seedlings with that of the non-treated plants and also with plants treated with methyl 2,4-dichlorophenoxyacetate. p-Cresyl 2,4-dichlorophenoxyacetate, 4 chloro-o-cresyl 2,4-dichlorophenoxyacetate, 3 methyl -4-chloro-2 nitro 2,4-dichlorophenoxyacetate and phenyl 2,4-dichlorophenoxythioacetate at the same concentrations had herbicidal activity equivalent to methyl 2,4-dichlorophenoxyacetate. Eugenyl 2,4-dichlorophenoxyacetate, bornyl 2,4-dichlorophenoxyacetate and 2-methyl-2,4-dichlorophenoxythioacetic acid had slightly less activity than the former substances. The remainder of the esters were much lower in activity and seemed to have little potential value.

A Study of Maggots Attacking Michigan Onions

MERRILL, L. G., JR., AND RAY HUTSON

Jour. Econ. Ent. 46: 678-680. 1953 (Journal Article 1484 from the Michigan Agricultural Experiment Station)

Observations over a period of years revealed discrepancies in the manner and time of attack by maggots affecting onions.

A rearing study conducted from 1949 to 1952, using more than 100 individual collections from field-infested and cull-pile onions, together with trapped and netted adults, revealed 52 species of maggots. Twenty species were reared from growing onions, *Hylemya antiqua*, *H. ciliicrura*, *Enmerus strigatus*, *E. tuberculatus*, and *Muscina stabulans* being the most abundant species. Apparently, from the data at hand, a definite seasonal succession of *H. ciliicrura*, *H. antiqua*, *Enmeris* spp., *Muscina stabulans* may be expected.

Identifications were made in cooperation with the Division of Insect Identification, U. S. Department of Agriculture, Washintgon, D. C.

The Supplementary Effects of Calcium Pantothenate and Aureomycin in a Low Protein Ration for Weanling Pigs

LUECKE, R. W.; J. A. HOEFER, AND F. THORP, JR.

Jour. Anim. Sci. 12: 605-610. 1953 (Journal Article 1488 from the Michigan Agricultural Experiment Station)

Sixty 25-pound pigs were used to study the effect of aureomycin on the pantothenic acid requirement. A low-protein basal ration (15.4 percent) containing 4.15 mg. of pantothenic acid per pound was used.

Five out of ten pigs fed the basal ration developed symptoms of locomotor incoordination. When aureomycin was added (5 mg. per pound) to the basal ration, an equal number of pigs developed deficiency symptoms indicating no sparing action of the part of this antibiotic for pantothenic acid. However, the addition of calcium pantothenate at a level of 2 mg. per pound to the basal ration prevented all symptoms of deficiency from appearing.

Study of Catalase in Erythrocytes and Bacteria. IV. Effect of Hydrogen Peroxide Concentration on the Catalase Activity of Bacteria

RICHARDSON, MARVIS, AND I. FOREST HUDDLESON

Archives of Biochem. and Biophysics. 47: 346-358. 1953 (Journal Article 1489 from the Michigan Agricultural Experiment Station)

Determinations were made of the hydrogen peroxide concentration necessary to demonstrate maximum catalase activity of intact cells of the genus *Brucella* and of *Micrococcus lysodeikticus*. It was found that within the genus *Brucella* the higher the catalase activity of the cell the higher the concentration of hydrogen peroxide required to demonstrate maximum activity. The maximum catalase activity of cells of *M. lysodeikticus*, which possessed a higher activity than any *Brucella* cells, was obtained with an intermediate substrate concentration, 1.2 *N* hydrogen peroxide.

The results show that for quantitative measurement of maximum catalase activity in intact bacterial cells the substrate concentration requirements must be established not only for each species, or variety of species, but for the same species grown under different conditions.

It has been demonstrated that availability of substrate is a limiting factor in the measurement of intracellular catalase in cells of the genus *Brucella* of moderate and high catalase activity and in cells of *M. lysodeikticus*. A higher concentration of hydrogen peroxide was required for the measurement of maximum catalase activity in these untreated cells than for that in cells of increased permeability and in extracts from the disintegrated cells.

Study of Catalase in Erythrocytes and Bacteria. III. Catalase Activity of Erythrocytes from Humans and Animals in Various Pathological States

RICHARDSON, MARVIS; I. FOREST HUDDLESON; MARY TRUSTDORF, AND RACHEL BETHEA

Archives of Biochem. and Biophysics. 47: 338-345 (Journal Article 1490 from the Michigan Agricultural Experiment Station)

Examination of blood specimens from 152 human beings in various pathological states revealed only one catalase index outside the normal limits. The diagnosis of the pathological condition of this case was indefinite.

Of 22 cows examined which were in an abnormal condition, only one had a catalase index outside the normal limits. This cow had a retained placenta and was receiving diethylstilbestrol.

The catalase indices of blood specimens from 5 of 44 dogs in various pathological states were slightly below the range of values found for normal dogs, and one index was definitely higher, that of a dog with anemia. The catalase indices of bloods from 2 horses, 14 pigs, and 5 guinea pigs in various pathological states were within the range of values found with normal animals. Normal limits for catalase index had not been established with a significant number of animals in these four species.

Owing to the wide range in catalase index values in normal individuals, definite and significant changes in catalase index could have occurred which would not have been evident as a deviation from the "norm."

A Study of the Seasonal Cycle of a Tetraphyllidean Cestode, *Proteocephalus stizosthethi* Hunter and Bangham, Found in the Yellow Pikeperch, *Stizostedion vitreum vitreum* (Mitchell)

CONNOR, R. S.

Jour. Parasitol. 39: 621-624. 1953 (Journal Article 1503 from the Michigan Agricultural Experiment Station)

A study of a seasonal cycle for a period of two years of the fish tapeworm, *Proteocephalus stizostethi* Hunter and Bangham, 1933, found in the yellow pikeperch (Walleye), *Stizostedion vitreum vitreum* (Mitchell), from Lake Erie is presented. Viable embryonated eggs were found only during June. Later in the summer, the worm was found in the fish and a new infection was obtained early in the fall which matured the following summer.

An Experimental Study on the Control of Pullorum Disease

PITAL, ABE; H. J. STAFSETH, AND E. H. LUCAS

Poultry Sci. 33: 134-139. 1954 (Journal Article 1508 from the Michigan Agricultural Experiment Station)

The ultimate purpose of this type of research is to find a drug or a combination of drugs that will eliminate the carrier condition of pullorum infected poultry. *In vitro* tests showed that S. *pullorum* No. 89817 is sensitive to low concentrations of aureomycin and chloromycetin. This organism is also sensitive to moderately low concentrations of penicillin. The latter seems to exert a slow

bactericidal action, while aureomycin and chloromycetin seem to be bacteriostatic. The use of proper concentrations of cobalt greatly enhanced the antibacterial action of penicillin. This was found in both *in vitro* and *in vivo* experiments. Aureomycin and chloromycetin were effective in reducing chick mortalities resulting from artificial infection with *S. pullorum*. Penicillin also reduced mortalities, but only at relatively high concentration levels. A decided reduction in penicillin levels may eventually be realized by the combined use of cobalt and penicillin. The value of all three antibiotic agents in prevention of carriers among recovered birds still remains to be determined. All treated birds received antibiotics for varying periods of time prior to infection. These same groups continued to receive antibiotics for the duration of the experimental period following inoculation.

The Effect of Feeding Concentrates with Different Moduli and Water Contents on the Eating and Milking Times in Dairy Cattle

DALTON, H. L.; C. F. HUFFMAN, AND N. P. RALSTON

Jour. Dairy Sci. 36: 1279-1284. 1953 (Journal Article 1510 from the Michigan Agricultural Experiment Station)

Two trials were conducted to determine the effects of finely, medium, and coarsely ground grain (1/16, 1/8 and 5 16 inch screens) and four water-to-concentrate ratios (air-dry, 0.5, 1.0, and 1.5 pounds of water per pound of concentrate) on the concentrate consumption rate and milking rate of dairy cows under barn feeding and pasture conditions. As the ratio of water-to-concentrate increased, there was a decrease in eating time. These results were explained on the basis of changes in the methods of eating concentrates with different water-to-concentrate ratios. When the water-to-concentrate ratio was 1.5 to 1, the cows drank the slurry concentrate. There was no significant change in the eating time for the three degrees of fineness. The cows ate air-dry concentrate more slowly when on good pasture than under barn feeding conditions. As the concentrate consumption rate decreased, there was a corresponding but not directly proportional decrease in the milking rate.

The Effect of Different Routes of Inoculation on the Adaptation of Infectious Bronchitis Virus to Embryonating Chicken Eggs

CUNNINGHAM, C. H., AND M. H. JONES

Proc. Book 90th Annual Meeting of the Am. Vet. Med. Assoc. 337-342. 1953 (Journal Article 1522 from the Michigan Agricultural Experiment Station)

Using embryo mortality as the criterion of adaptation of the virus through seven serial passages in eggs, the highest mortality rate was produced by amnionic inoculation followed in decreasing order by allantoic cavity and chorioallantoic membrane inoculation. Characteristic lesions were observed in the embryos. Low mortality rates followed yolk inoculation, and no specific changes were observed in the embryos. The eggs were from an infectious bronchitis-immune flock, and yolk antibodies probably neutralized the virus. The allantoic cavity route of inoculation is more desirable than the amnionic route for isolation of field strains of the virus because of greater ease of inoculation and the appearance of characteristic pathological alterations as early as the third postinoculation day.

Value of Progesterone and Estradiol on Growth and Finish in Broilers

LIBBY, D. A.; P. J. SCHAIBLE; J. MEITES, AND E. P. REINEKE

Poultry Sci. 32: 1086-1088. 1953 (Journal Article 1528 from the Michigan Agricultural Experiment Station)

Male and female White Rock chickens were implanted with the two female hormones at 7 weeks of age and carried to 11 weeks in growing batteries. Neither progesterone nor estradiol, or the combination of the two, significantly improved the body weights of either the males or females, but there was a slight improvement in the finish of all treated groups. Feed conversion was not improved by the use of the hormones singly or in combination. Comb weights were reduced by both hormones but not in an additive manner. However, the combination of estradiol and progesterone was additive in increasing liver weights, which were also increased by the single hormones. Progesterone pellets were less than half absorbed during this trial, whereas estradiol pellets were not recoverable.

The Association of Listeria Monocytogenes with Abortion

STOCKTON, J. J.; LISA NEU; W. S. CARPENTER, AND M. L. GRAY

Jour. Am. Vet. Med. Assoc. 124: 102-105. 1954 (Journal Article 1529 from the Michigan Agricultural Experiment Station)

A literature survey is presented of the reported occurrences of *Listeria monocytogenes* associated with abortion in man and animals. A case is described involving the isolation of this organism from an aborted bovine fetus. This is the fourth reported occurrence of the association of *L. monocytogenes* with bovine abortion in the United States.

Changes in Composition of Crude Egg Protein Preparations When Kept Under Refrigeration for Several Years

EVANS, R. J.; J. A. DAVIDSON, AND DORIS BAUER

Poultry Sci. 33: 208-209. 1954 (Journal Article 1533 from the Michigan Agricultural Experiment Station)

Crude egg yolk and white protein preparations were assayed for methionine, cystine, and lysine 8 and 49 months after preparation. Acid hydrolysis and microbiological assay procedures were used. Little change in methionine concentration occurred in the 41 months between the two sets of assays. There was a 14.0 percent decrease in the lysine concentration and a 21.6 percent decrease of cystine in the egg proteins.

The Relationship Between Live Hog Scores and Carcass Measurements

BRATZLER, L. J., AND E. P. MARGERUM, JR.

Jour. Anim. Sci. 12: 856-858. 1953 (Journal Article 1534 from the Michigan Agricultural Experiment Station)

Four hundred and thirty-four live hogs were scored for length, finish and preferred cut percentage by three judges including one packing company live-

stock buyer. After slaughter the carcasses were measured and weights of cuts obtained. Correlation coefficients obtained between live estimation and carcass measurements showed that preferred cut yield was most difficult to estimate, while a closer relationship exists between live scores for finish and length and carcass measurement.

The Growth Regulating Properties of Some Beta-Naphthylalanines

HAMNER, C. L.; T. L. REBSTOCK, AND H. M. SELL

Sci. 119: 217-218. 1954 (Journal Article 1545 from the Michigan Agricultural Experiment Station)

Based on a cucumber seed germination test, the following B-naphthylalanines were tested as possible growth regulators: B-1-naphthylalanine, glycyl-B-1-naphthylalanine, B-3-thianaphthylalanine, carbobenzoxyglycyl-B-1-naphthylalanine, carbobenzoxyglycyl-B-2-naphthylalanine, and B-2-naphthylalanine. The compounds produced abnormal modification of root growth, besides causing inhibition of growth of the main root. Beta-1-naphthylalanine, glycyl-B-1-naphthylalanine, B-3-thianaphthylalanine, and B-2-naphthylalanine produced the greatest inhibition of root growth. The respiratory activity of seeds treated with B-1-naphthylalanine, glycyl-B-1-naphthylalanine, and B-3-thianaphthylalanine could be correlated with the growth pattern observed in the roots. These compounds produced an effect similar to that observed with 1-naphthaleneacetic acid.

Observations of Dairy Cow Activities in Loose-Housing

LEWIS, R. D., AND J. D. JOHNSON

Jour. Dairy Sci. 37: 269-275. 1954 (Journal Article 1548 from the Michigan Agricultural Experiment Station)

The activity patterns of a herd of Brown Swiss cows wintered in a loose-housing barn with outside self-feeding of hay and silage are described. The cows spent one-half or more of the day resting or loitering in the lounge. During the rest of the day a little more than half was devoted to eating, while the rest was spent in loitering in the yard. Rectal temperatures and respiration rates of cows in loose-housing were lower than for those in a stanchion barn. At first, the pulse rate was higher in cows in loose-housing but late in the winter the rate dropped to a level below that of cows in stanchion barns.

Experimental Variables in Predicting Protein Minima for Rats

KELLEY, LOUISE, AND M. A. OHLSON

Jour. Nutr. 52: 325-335. 1954 (Journal Article 1551 from the Michigan Agricultural Experiment Station)

Data for predicting minimum protein requirements for 150-gram albino rats were obtained from feeding diets with 0 to 10 percent dried whole egg and 4 or 12 percent lard in cross-over-type experiments. Adjustment to metabolic stress imposed by low-protein intakes was reflected in diminished nitrogen excretion of rats. Predicted minimum requirements were influenced by changes in protein

stores of rats during the course of the experiment and by the addition of fat to experimental diets. Utilization of egg nitrogen was almost as efficient in the area above maintenance of nitrogen equilibrium as below. Further investigation of the problem of estimating protein requirements from regression curves in the area of diminishing efficiency of utilization is recommended.

Use of the Thymus Gland in Chicks to Elucidate Interrelationships Between Pteroyl-Glutamic Acid and Biologically Related Substances

BRODY, GERALD

Sci. 118: 720-721. 1953 (Journal Article 1553 from the Michigan Agricultural Experiment Station)

The dramatic atrophy of the thymus gland in the absence of PGA was used to elucidate the interactions of PGA with other compounds. The results obtained offer additional evidence to support the concept that leucovorin was biologically equivalent to PGA plus vitamin B_{12}. The addition of vitamin B_{12} to a basal diet deficient in both PGA and vitamin B_{12} had no effect on thymic growth. Likewise, the addition of vitamin C to this basal diet did not stimulate the growth of the thymus. However, the addition of both vitamin C and vitamin B_{12} did increase the thymus weight but did not approach the level produced by the addition of PGA to the diet. On the other hand, the relative weight of the thymus gland in the presence of leucovorin is almost equal to the thymus weight in the presence of both PGA and vitamin B_{12}. The weight of the thymus in the presence of leucovorin is significantly greater than the weight produced by PGA alone or by vitamin B_{12}.

Performance of Dairy Plant Receiving Rooms

HALL, CARL W.

Agr. Engin. 34: 832-834. 1953 (Journal Article 1563 from the Michigan Agricultural Experiment Station)

The results of engineering studies are used to recommend the most economical size of conveyor, weigh can, and rotary and straight-away can washers. The over-all labor efficiency of eight receiving rooms is expressed in terms of man-minutes required to handle 100 cans. An analysis of the causes of delays illustrates the main difficulties in the operation of the receiving room.

Engineering Analysis of Bulk Handling of Milk in Michigan. Part I. Farm Bulk Tanks

HALL, CARL W.

Milk Plant Monthly. 42: 13-14. 1953 (Journal Article 1570 from the Michigan Agricultural Experiment Station)

Four farm bulk milk routes were developed in Michigan from January to September, 1953. Several additional routes are being planned. Most of the bulk milk tank installations are in stanchion barns. The milk is picked up every other day. Costs are being obtained for both the direct-expansion and sweet water

bulk tanks. The original cost of the direct-expansion tank is more expensive but the cost of electricity for operation is less than the sweet water tank. Over a 12- to 15-year period, not considering repairs, the total cost of operation of the two types of tanks is approximately equal.

Paper Versus Glass

HALL, CARL W.

Food Engin. 26: 101-102. 1954 (Journal Article 1572 from the Michigan Agricultural Experiment Station)

The filling operation is the key to all the operations from the storage tank to the refrigerated bottle or carton storage. Because the bottle or carton is the major item of cost, the total cost of the bottling operation is almost the same as that of the different sized filler. The paper carton operation costs approximately $0.90 per 100 pounds of milk (1 cent a quart more than the glass filling and bottle washing operation). Three charts are presented which can be used for determining the unit cost of operation of the glass bottling machine, bottle and case washer, and paper carton former and filler machine.

How Efficient Can the Dairy Cow Become?

HOGLUND, C. R.

Jour. Dairy Sci. 36: 1348-1351. 1953 (Journal Article 1575 from the Michigan Agricultural Experiment Station)

The efficiency with which a dairy cow converts feed and other resources into milk is determined by factors that are inherent with the cow as well as those that are man-made or man-controlled. The inherent productivity of a cow is by far the most important single factor that influences efficiency in producing milk. Upbreeding a herd from 7,000 pounds to 10,000 pounds average production reduces feed input in producing 100 pounds of milk by 20 percent and more than doubles labor and management returns. Improving the quality of roughage can reduce feed costs by as much as 10 to 25 percent. Dairy farmers must adjust their feeding practices to changes in price relationships between feed and milk if maximum efficiency is to be attained. Disease and environmental conditions also affect the efficiency with which a cow converts feed into milk.

The Rate of Penetration of Sweetose and Sucrose Into Different Size Pickles

FABIAN, F. W., AND R. N. BERKMAN

The Canner. 118: (4), 9-11, 34. 1954 (Journal Article 1579 from the Michigan Agricultural Experiment Station)

A study was made of Sweetose as a pickle sweetner. It was compared with sucrose and with a combination of 15 percent Sweetose and 85 percent sucrose. The results showed that there was very little difference in the rate of penetration between Sweetose, sucrose and the combination of Sweetose and sucrose. At first all sugars penetrated the 15,000 size pickles faster than they did the 3,000 size. However, there was not much difference in the time required for both the small and large sized pickles to reach equilibrum.

Engineering Analysis of Bulk Handling of Milk in Michigan. Part II. Tanker and Plant Data

HALL, CARL W.

Milk Plant Monthly. 43: 41-42. 1954 (Journal Article 1592 from the Michigan Agricultural Experiment Station)

The paper presents results of a time-and-motion analysis on tanker and plant operations for bulk milk handling. These data are valuable for planning future routes and for analyzing present routes. The equipment used in the first bulk milk route in Michigan is described.

With the elimination of the receiving room operation, the dairy plant can reduce their costs and pay more to the farmer for his milk. A table is presented which includes the cost of operation of an efficient receiving room.

Newly Developed Nylon Units for Measuring Soil Moisture in the Field

BOUYOUCOS, G. J.

Highway Research Abstracts. 24: 29-32. 1954 (Journal Article 1593 from the Michigan Agricultural Experiment Station)

The nylon units devised in 1948 have been improved. The original units were inaccurate in relatively dry soil because the metal frame prevented good contact between the nylon surfaces and the soil. The new nylon units, constructed by encasing the old units in plaster-of-paris, possess the desirable characteristics of the plaster-of-paris blocks and the original nylon units. They are sensitive and are efficient through a wide variation in soil moisture. They are not appreciably affected by salts in the soil solution.

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